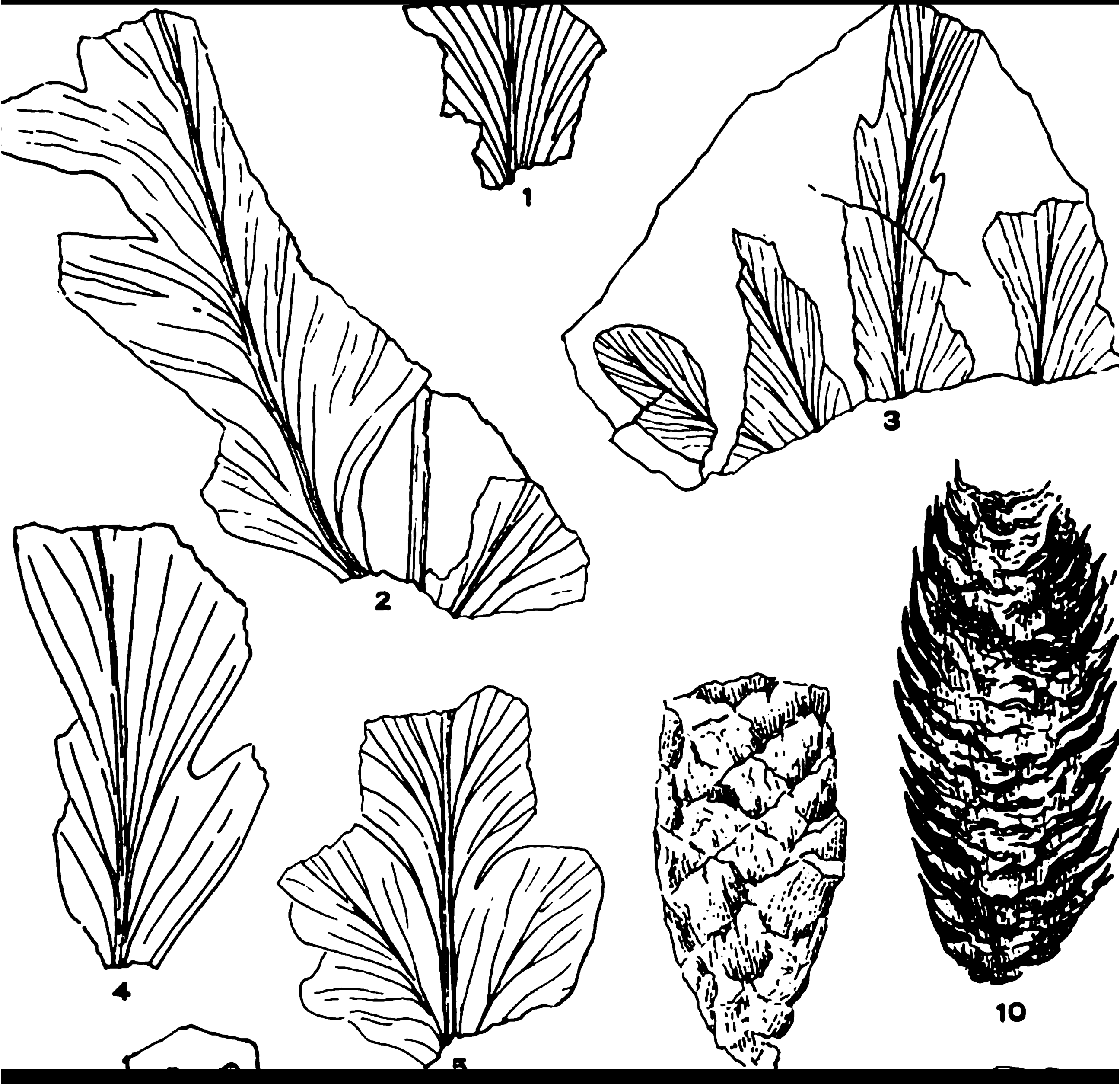

Memoirs of the New York Botanical Garden

New York Botanical Garden

MEMOIRS

OF THE

NEW YORK BOTANICAL GARDEN

VOL. III

STUDIES OF CRETACEOUS CONIFEROUS REMAINS FROM KREISCHERVILLE, NEW YORK

BY

ARTHUR HOLLICK, PH.D.

NEW YORK BOTANICAL GARDEN

AND

EDWARD CHARLES JEFFREY, PH.D.

HARVARD UNIVERSITY

Issued May 20, 1909.

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PREFACE

This Memoir is designed to present the results derived from critical studies of coniferous remains from certain of the Cretaceous deposits at Kreischerville, Staten Island, New York, especially from two exposures, locally known as the Androvette pit and the Drummond pit—excavations made for the purpose of obtaining clay and sand for the manufacture of fire-brick, terra-cotta, etc.

The material upon which the studies were based was secured largely through the cordial coöperation of the Messrs. Androvette, owners of the property, by whom permission was given to collect specimens at all times, and also to make special excavations in search of desirable material, and who provided, at their own expense, the labor to prosecute the work of digging and rough handling of the material.

In connection with the preparation, study and illustration of the material the following individual work of the authors is indicated. The senior author is responsible for the selection and preparation of the larger specimens and for identifications based upon external characters, this part of the work having been done at the New York Botanical Garden; the junior author for the selection, preparation and microscopical examination of the smaller specimens and lignites, and for identifications based upon internal structure, these features of the work having been accomplished in the Phanerogamic Laboratories of Harvard University. Plates 1 and 2 are reproductions of photographs taken by the senior author; Plates 3–6 of drawings of selected specimens made by the senior author; Plates 7–10 of drawings made by the senior author from enlarged photographs of selected specimens made by the junior author; Plates 11–29 of photomicrographs of sections made by the junior author.

In all other respects this Memoir is a joint contribution.

ARTHUR HOLLICK,
New York Botanical Garden.
EDWARD C. JEFFREY,
Harvard University.

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STUDIES OF CRETACEOUS CONIFEROUS REMAINS FROM KREISCHERVILLE, NEW YORK[1]

INTRODUCTION

Previous References to the Paleobotany of the Locality

In the early reports of the New York State Geological Survey may be found several references to the geology of the vicinity of Kreischerville, but they are very brief, and the fossil plant remains in connection with the Cretaceous deposits receive only a few meager lines of description.

Dr. Lewis C. Beck refers to the lignite, and says:[2] "On Staten Island, near Rossville, is a stratum of this mineral, from three to six inches in width, apparently below high-water mark. Sometimes it has the colour and appearance of wood; at others it is quite compact, and has a dark brown or black colour, and resembles jet . . . Probably, also, amber will be found here, as it accompanies a similar formation at South Amboy, in New Jersey, a few miles from the above locality." Subsequently[3] he refers to the Rossville lignite as having "the appearance of wood charred by the action of an acid," and suggests that it probably owes its origin to the action of the excess of acid which the clay contains "upon drift wood from time to time deposited on this shore of the island." From these descriptions it may be inferred that the ideas of those days in regard to the nature, origin and antiquity of this lignite were exceedingly vague.

[1] Investigations prosecuted with the aid of a grant from the Botanical Society of America.

[2] First Ann. Rept. N. Y. State Geol. Surv. Assembly Document No. 161, Feb. 11, 1837, p. 59.

[3] Third Ann. Rept. N. Y. State Geol. Surv. Assembly Document No. 275, Feb. 27, 1839, p. 16.

Mr. William W. Mather also mentions the abundance of lignite in the clay exposure in this part of Staten Island, and says[4] that the clay is "similar in its general characters to that of Cheesequake and Matavan Point, on the Jersey shore, and it appears to have a similar geological position."

Practically the same notes may also be found included in the final reports by these authors,[5] but after the issue of these there followed a period of some forty years during which nothing of a scientific character appears to have been recorded, or at least published, in regard to the deposits or their accompanying organic remains.

In 1881 Dr. Nathaniel L. Britton read a paper before the New York Academy of Sciences, entitled "On the Geology of Richmond County, N. Y.,"[6] in which the Cretaceous age of the deposits in question is recognized as settled, and he says (p. 172): "Lignite and pyrites are frequently found in the clay excavations. . . . As the lignite dries, it cracks up into little pieces, thus destroying the texture of the fossil wood composing it, and making it very difficult to retain good specimens. No fossil leaves or shells have been taken from the clays . . . but it is not improbable that they will be found at some future time, when the excavations are more advanced than at present."

During this same year the Natural Science Association of Staten Island was organized and the investigation of local geological features was begun on a systematic basis. In 1885 the prediction made by Dr. Britton was verified, and in the account of the meeting of the Association held on December 12, 1885, may be found the following record:[7] "Mr. Hollick stated that an important find of fossil vegetable remains was discovered in the Kreischerville fire clay on Nov. 15; but that it was deemed best to merely place the fact upon record, and to leave the full account of the same until the material collected had been studied more carefully."

Subsequently, at the meeting held on February 13, 1886, these remains were reported upon as follows:[8] "All of our specimens were

[4] Second Ann. Rept. N. Y. State Geol. Surv. Assembly Document No. 200, Feb. 20, 1838, p. 137.

[5] Nat. Hist. N. Y., Pt. III, Mineralogy, pp. 185, 191, 192. 1842.—Ibid., Pt. IV, Geology. Geol. First Geol. Dist., pp. 266, 267. 1843.

[6] Annals N. Y. Acad. Sci. 2: 161–182. *pls. 15, 16.* 1882.

[7] Proc. Nat. Sci. Assoc. Staten Island 1: 27. 1885.

[8] Proc. Nat. Sci. Assoc. Staten Island 1: 31. 1886.

found in a narrow stratum, nowhere more than a foot in thickness, near the surface of the bed. The stratum was conspicuous from its dark color, due to the mass of lignified vegetable matter which it contained. Much of this was broken twigs and branches, some pieces being quite large and showing the woody texture very beautifully; they, however, fell in pieces upon exposure to the air." A list of the angiosperm genera, determined from the leaves, is given, and the final paragraph on the gymnosperms is to the effect that "Pine needles are distributed plentifully throughout. . . . Another conifer which has left its mark, is so close to Sequoia that it has been referred to that genus. . . . There are also little masses of a yellow substance here and there which I take to be a fossil gum or amber. This could, however, only be determined by chemical analysis. Fruits and seeds should be sought carefully, as they are generally quite satisfactory to determine, being less liable to destruction than the leaves."

The excavation from which these remains were obtained was shortly afterwards partly filled in, and for several years no further collections were made; but in 1892 new excavations again exposed the plant-bearing layers, and specimens collected were reported upon at the March meeting of that year, viz.:[9] "Mr. Davis presented unusually fine specimens of lignite, apparently coniferous, from the clay beds at Kreischerville. The specimens were of the appearance and consistency of jet and contained considerable amber. . . . Mr. Hollick stated that a record should be made of the re-discovery, since the last meeting, of plant remains in the clay pit at Kreischerville, where they were first found and noted six years ago. . . . As on the former occasion, however, the specimens found were too fragmentary for accurate determination. They occur thickly massed together in confusion, in a stratum averaging, in the recent exposure, about two feet in thickness. It was not found possible to so separate them as to obtain perfect specimens."

These discoveries, meager as they were, nevertheless served to definitely correlate the Staten Island clays with those of New Jersey and to determine their Cretaceous age beyond further question.

Occasional fragmentary plant remains were brought to light from time to time subsequently, as new excavations were made, and some

[9] Proc. Nat. Sci. Assoc. Staten Island 3: 12. 1892.

of these discoveries also may be found recorded, as follows:[10] "A bed of fossil leaves, similar to those found at Kreischerville, has recently been discovered at the bottom of a clay pit at Green Ridge, but the specimens were too fragmentary for determination. The discovery was made by Mr. Heinrich Ries, while engaged in examining the clays of the Island for the New York Geological Survey. . . . Mr. Davis presented a finely preserved specimen of a conifer, from one of the Kreischerville clay pits, identified provisionally as a *Juniperus*."

It was about this time that what is known as the Androvette pit was opened up, which has since yielded the bulk of the material upon which our work is based. The first specimens found in this pit were collected by Mr. Wm. T. Davis,[11] but it was not until some years afterward that the richest part of the plant-bearing layers were uncovered. During the autumn of 1904 specimens of amber, leaves and other remains were found in abundance and a systematic study of the deposits was begun by the senior author. Preliminary reports were made to the Natural Science Association of Staten Island,[12] and a brief note was published, with illustrations, in the Journal of the New York Botanical Garden for March, 1905. Particular attention was given to the amber and this feature of the deposits was made the basis of a paper which was read at the Philadelphia meeting of the Botanical Society of America, in 1904, under the title "The Occurrence and Origin of Amber in the Eastern United States."[13] It was this paper which led to communication between the authors and to the joint work subsequently undertaken, the first result of which was a preliminary paper, entitled "Affinities of Certain Cretaceous Plant Remains Commonly Referred to the Genera Dammara and Brachyphyllum,"[14] designed to indicate the value of critical examination of the Kreischerville lignitic material. The investigations there outlined have since been systematically prosecuted, both in the field and in the laboratory, and the results thus far attained, in so far as the coniferous remains are concerned, are set forth in this Memoir. Other contributions, also based either wholly or in part on the Kreischerville material, are as follows:

[10] Proc. Nat. Sci. Assoc. Staten Island 3: 20. 1892.

[11] Proc. Nat. Sci. Assoc. Staten Island 3: 23. 1892.

[12] Proc. Nat. Sci. Assoc. Staten Island 9: 31. 1904.—Ibid. 35. 1905.

[13] Amer. Nat. 39: 137–145. *pls. 1–3.* 1905.

[14] Amer. Nat. 40: 189–215. *pls. 1–5.* 1906.

Hollick, A. "Origin of the Amber Found on Staten Island." Journ. N. Y. Bot. Gard. 7: 11, 12. 1906.—"A Fossil Forest Fire." Proc. Staten Island Assoc. Arts & Sci. 1: 21–23. 1906. —"Insect Borings in Cretaceous Lignite from Kreischerville." Ibid. 23, 24.

Jeffrey, E. C., and Chrysler, M. A. "On Cretaceous Pityoxyla." Bot. Gaz. 42: 1–15. *pls. 1, 2.* 1906.

Jeffrey, E. C. "The Wound Reactions of Brachyphyllum." Annals Bot. 20: 383–394. *pls. 27, 28.* 1906.—"Araucariopitys, a New Genus of Araucarians." Bot. Gaz. 44: 435–444. *pls. 28–30.* 1907.—"On the Structure of the Leaf in Cretaceous Pines." Annals Bot. 22: 207–220. *pls. 13, 14.* 1908.

Description of the Deposits

Stratigraphic Relations.—A complete series of the Kreischerville deposits shows Cretaceous clays and sands at the base, apparently including both the Raritan and the Cliffwood formation, above which are sands and gravels of Tertiary or early Pleistocene age, probably referable to the Pensauken formation, with Quaternary boulder till at the surface; but all of these deposits are seldom represented in any one section and one or more of the formations may be locally wanting, or their exact stratigraphic relations in certain of the sections may be more or less obscurely defined. It is often difficult, for example, to differentiate satisfactorily between the two Cretaceous formations, on account of their general lithologic similarity and the fact that certain well-known floral elements are common to both, while in certain sections it is not easy even to determine whether only one of the formations is represented or whether both are present, for the reason that the line of contact between them is generally not well defined. Cross-bedding, and the occurrence of lenticular beds or pockets of lignitic debris between the sand and clay layers, are conspicuous original features of the deposits at certain levels, indicating running water conditions of deposition, while elsewhere there are pronounced secondary deformations, due to ice pressure, represented by faulting and folding of the strata.

The stratigraphic relations are therefore liable to be misinterpreted unless they are subjected to careful study. As a rule, however, the lower white and gray clays and sands are regarded as

referable to the Raritan and the upper red and buff sands to the Cliffwood.

The phenomena of cross- and lenticular-bedding is best exemplified in the Androvette pit, and some of the sections there exposed also afford the best examples of the stratigraphic relations between the several deposits represented. The most extensive vertical section in this pit is shown in Plate 1. The contact between the Raritan and Cliffwood formations is comparatively well defined and the eroded surface of the latter, together with the overlying unconformable Pensauken sands and gravels, are finely exposed. Boulder till is not present in this section, which underlies a limited unglaciated area.

In the Drummond pit the Cretaceous deposits are almost exposed at the surface of the ground. The Pensauken sands and gravels are lacking, having been entirely eroded by glacial action, but they are represented, to a certain extent, as more or less conspicuous constituents of the till, which rests in a thin layer directly on the Cretaceous deposits. These latter here consist of relatively thick clay strata, in which sandy layers are not conspicuous features, and cross-bedding or other indications of the action of running water are wanting; but well defined faulting and slight arching or folding, evidently caused by the weight and thrust of ice, are quite apparent. A view of a portion of this pit is shown in Plate 2, where the arching of the strata, in a gentle anticline, may be noted. These clays are located at a considerable elevation above and to the south of those in the Androvette pit, and as the normal dip of the strata is towards the southeast they should, theoretically, represent a higher and more recent geological horizon than the latter; but the deformation and disturbance to which they have been subjected renders it somewhat hazardous to venture any positive opinion on this point.

Occurrence and General Characters of the Plant Remains.—The only plant-bearing beds belong to the Raritan Cretaceous deposits, and plant remains of one kind or another are present in most of the layers. They are sometimes represented merely by finely comminuted charcoal or lignite, but larger fragments and branches and logs of lignite, often charred on the exterior and impregnated or coated with pyrite, are more or less abundant. In many of the latter amber occurs in the interstices. In addition to the charcoal and lignites the remains also include irregular fragments and drops or "tears" of

amber, twigs, bark, cones and cone scales, seeds, leaves and leaf impressions.

Most of the logs and larger lignitic fragments were found as isolated specimens scattered through the clay strata in the Drummond pit, while the finer material and nearly all of the leaves and leaf impressions were obtained either from a bed of closely packed lignitic and charcoal debris, or from the accompanying clay layers, in the Androvette pit. Many of the leaves, when first uncovered, were found to be beautifully preserved, in the form of thin, brown or black carbonaceous films, but this largely disintegrated and disappeared on exposure to the air, leaving only faint impressions to represent the specimens in most instances. A large majority were of angiosperms, and as these were the first remains to attract attention, an erroneous impression was originally formed in regard to the relative proportions of the angiosperms and gymnosperms in the flora. The latter were thought to be a comparatively insignificant element, and it was not until subsequently, when the lignites and lignitic debris had been examined microscopically and the amber had been analyzed chemically, that a true conception of the actual abundance of the gymnosperms was obtained; as apparently all of the amber, nearly all of the lignites and the larger part of the lignitic debris were found to belong to this latter class of vegetation. In other words, if the characters of the leaf remains alone should be considered the flora would appear to have been largely angiospermous, while judged solely from the lignitic remains the gymnosperms would seem to have been the dominant class. It is probable, however, that the relative proportions of each class among the leaf impressions affords the more accurate basis for conclusions in this connection, inasmuch as all leaves deposited with the fine clay would have an equal chance of preservation in the form of impressions, irrespective of texture or power of resistance to decay, whereas the wood of angiosperms as a rule yields more rapidly to decay than that of gymnosperms, and it would therefore be less likely to be preserved in the form of lignite; and we can state as a matter of fact that of the former the few specimens found were badly decayed and unsatisfactory for study, while of the latter the specimens were not only abundantly represented by many of them were unusually well preserved and were capable of being sectioned and the internal structure determined with accuracy.

If these facts and conclusions are considered as a whole, it is probably fair to assume, from the evidence which they present, that the relative proportions of the two classes of vegetation in the flora were about the same as at the present time, but that the gymnosperms included a larger number of species than now obtain.

Methods Pursued in the Examination of the Material

Impressions in the Clay Layers.—Nothing special need be described in regard to the methods pursued in the examination of the remains and impressions obtained from the clay layers, as this material was not different from that with which the paleobotanist ordinarily has to deal. All of the larger specimens with well defined external characters were merely drawn natural size, in order to show the general appearance which they present to the unaided eye, and to enable comparisons to be made with Cretaceous species elsewhere similarly figured. These are included on Plates 3–6.

Lignitic Material.—The material composed of lignitic remains, especially such as formed the mass of the finer debris, was found to require special preliminary treatment in order to prepare it for critical examination, and some account of the methods pursued in its treatment and preparation has seemed to us advisable, especially as the results attained are almost entirely due to improved technique. This material, while it occurs in the form of a concentrated lignitic layer, contains a considerable admixture of clay and very fine sand. Further, even where the massed debris is almost pure lignite, it is so compacted together by pressure and chemical action that it is impossible to isolate the fragments satisfactorily by ordinary mechanical methods. It was ascertained, however, that maceration in 1–3 per cent. caustic alkali had the double effect of separating the fragments from the matrix and from each other. All such material was therefore subjected to this preliminary treatment.

After maceration for two or three days in the weakest solution of alkali which would effect isolation of the fragments, the disintegrated material was washed carefully with runnning water, on trays made of mosquito-screen wire, during which process, in order that the weight of the mass might not break the more delicate isolated fragments, the trays were kept immersed almost to their tops. The latter precaution was found to be a highly important factor in securing

good specimens. It was also found advantageous to first screen off the coarser fragments by means of a quarter-inch mesh, thus facilitating the subsequent examination of the finer material for valuable fragments, as the larger pieces are seldom well preserved and therefor merely serve to obscure those of greater value.

The critical examination of the material was carried on by means of the dissection microscope and a lens of two- or three-inch focus. Such a lens has a large field and magnifies sufficiently to enable all the fragments of value to be readily picked out. The material thus selected has, of course, to be sectioned for the study of any internal details of diagnostic value, and, as a preliminary step, mineral matter is removed by treatment with a rather strong solution of hydrofluoric acid. This serves to eliminate everything but iron pyrites, which has to be accepted as a necessary evil, since any reagent which will effect its removal also destroys the material. However, it is possible in most cases, on account of the relative abundance of the specimens yielded by the process of maceration described above, to select those fragments which are free from pyrites for subsequent examination. After treatment with hydrofluoric acid for two or three days, the material, after careful washing and dehydration, is transferred to successively thicker solutions of celloidin in synthol-ether, equal parts. The celloidin containing the objects is finally thickened up by the addition of chips of celloidin, until it will no longer run in the cold. The entire process of embedding is carried on in a paraffine bath, at a temperature of about 60° Centigrade, in wired bottles. When the celloidin has been sufficiently thickened the pieces of lignite are removed with forceps, care being taken to cool the bottle beforehand and to have the objects covered with a thick layer of celloidin. They are then plunged into chloroform, where they remain several hours until the celloidin has become thoroughly hardened. Finally they are transferred to a mixture of equal parts of 90 per cent. alcohol and glycerine, where they may be kept indefinitely.

When the objects are to be cut, they are attached to the object-carrier of the sliding microtome (Jung-Thoma), having previously been cemented to blocks of wood by means of thin celloidin, which is allowed to dry hard.

Material prepared by the above method furnishes thin and satisfactory sections, which are well suited for photomicrographic pur-

poses, since the natural brown hue of the lignite serves as an admirable natural stain. Often, even in thin sections 5 and 10μ in thickness, which are readily secured by the above method, the hue is too intense for the resolution of fine details. In such cases the sections may be very readily bleached by the use of chlorine water, which acts very quickly and without injury to the material. Peroxide of hydrogen was also employed for this purpose but is not at all satisfactory as a bleaching agent for lignites. When the sections are of the desired shade they are dehydrated by means of absolute alcohol, to which a few drops of chloroform have been added to prevent the softening of the celloidin matrix which holds the sections together. Thence they are transferred to benzol or xylol for clearing and are mounted in Canada balsam. It is necessary on account of the use of photographic methods of reproduction to have the sections perfectly flat. This is effected by allowing them to set under weighted cover-glasses in a warm place. Subsequently they are subjected to still further pressure by means of photographic clips, which are prevented from breaking the thin cover-glasses by slices of cork or wood, interposed between the cover and the clip. During this process they are kept in the paraffine oven to promote the further hardening of the balsam.

The methods described above are somewhat laborious, but the results obtained appear to fully justify the expenditure of effort, as photomicrographs are readily obtained showing every detail of structure with great fidelity, with a small fraction of the time required for the making of drawings.

In the case of material from which it was desirable to obtain an enlarged facsimile of the external features, the following method was pursued: The objects were placed in a watch-glass, the bottom of which had previously been covered with a smooth coating of black wax, flooded with alcohol and illuminated with the concentrated rays of a powerful electric lamp. Magnifications of ten or more are readily obtained in this way by the use of suitable modern lenses. The powerful light allows a stopping down of the aperture of the lenses to a sufficient degree to bring about sharpness at all depths of focus, without any material loss of brilliancy, in spite of the almost black color of the lignites. After the negative is secured, the black background, which is necessary for throwing up the surface details, is readily painted out by one of the numerous spotting

varnishes used by photographers. A number of the smaller fragmentary remains were photographed in this way, and from the photographs drawings were made in order to emphasize certain critical features not otherwise apparent. These are reproduced on Plates 7–10, and photo-micrographs of the sections on Plates 11–29. The latter may be advantageously examined with a hand lens.

Amber.—Under this name we include all of the resinous material found in connection with the deposits, of which a considerable amount was collected. The larger fragments were secured during the progress of excavation, without any special search being made for them, while most of the smaller pieces were obtained as an incidental result of the subsequent maceration of the lignitic debris. In numerous instances, also, it was found *in situ* in the interstices of the lignites, as will be described further on in the discussions of certain of these remains. It is manifest that its exact origin could be determined only when found as an actual constituent of some lignite with structure sufficiently well preserved for identification.

The isolated fragments may have been derived from several different sources. They probably include both bark and wood amber and represent, so far as their origin is concerned, several different genera and species of trees, and hence an effort was made, by means of chemical analysis, to determine approximately the origin of some of this material. Specimens analyzed by Dr. William J. Gies, of Columbia University, gave the results set forth in the following report:

COLUMBIA UNIVERSITY
DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY

March 22, 1907.

DR. ARTHUR HOLLICK,
N. Y. Botanical Garden.

Dear Dr. Hollick: The samples of American fossil resin [from Kreischerville] submitted to me by you for chemical analysis were found to consist of typical amber. This conclusion is justified not only by the fact that the samples closely resembled well known varieties of amber in all of the grosser aspects, such as hardness, color, specific gravity, etc., but, also, by the observation that the differential chemical qualities of your samples and those of *Succinite* were essentially the same.

Of the chemical results that Dr. Meyer and I have obtained in our study of your samples, the following, taken collectively, warrant the deduction that we were dealing with true amber (*Succinite*):

1. On destructive distillation, amber oil was obtained, which contained succinic acid.

2. When heated in a narrow tube to incipient decomposition, the fumes contained sulfur in the form of sulfid.

3. The powdered material was more or less soluble in epichlorhydrin, ether and alcohol.

4. Numerous determinations of elementary composition yielded the following average data:

C	H	O	S	Ash	Volatile matter at 100° C.
77.87	9.11	12.57	0.35	0.10	0.4

Nitrogen and phosphorus were absent.

These results accord with the specific data that have been accumulated by various observers for *Succinite*. Some of our quantitative results indicate that your samples of amber are in some respects somewhat different, though not in essential characters, from most ambers already described. This is a result of no special significance, however, for ambers are variable mixtures of resinous products and chemical differences of minor import are recognizable whenever the data for composition of different samples are compared.

Very truly yours,
WILLIAM J. GIES.

DESCRIPTIONS OF SPECIMENS

ABIETINEAE

Genus PINUS Linnaeus

Remains of the genus *Pinus* are abundantly represented, in material from both the Androvette and the Drummond pit, by wood, bark, amber, dismembered cones, cone scales, fragments of needles, and short shoots which include the basal portions of needles and the reduced axes to which they belonged.

The short and fragmentary needles are especially abundant in the fine lignitic debris of the Androvette pit and are also found, to some extent, in the clay layers, but in no instance was a perfectly preserved fascicle of leaves obtained, although they clearly show the presence

of a number of different species, some with two and others with three, four and five needles in each fascicle, and some of the fragments of the needles are two inches long, indicating a greater length when entire. In all cases where the basal portions of the fascicles are preserved a persistent sheath is also present, generally forming a membranous vagina, such as is usually found in living species belonging to the sections *Pseudostrobus, Pinea* and *Pinaster.* One, possibly two species, show a type of sheath unusual among living hard pines, consisting of loose, short bracts, like those occurring in the section *Strobus,* and in *Pinus edulis* Engelm. and related species of soft pines, but not deciduous as in these and other pines of the same group.

These remains, when sufficiently well preserved, possess one feature which, in general, serves to distinguish all of the Cretaceous pines thus far examined by us from those now living, and that is the very wide zone of transfusion tissue surrounding the leaf bundles. This transfusion tissue differs from that found in living pines in that there are few or no parenchyma cells mixed up with the transfusion elements proper. The endodermal sheath separating the transfusion tissue from the mesophyll is also less clearly marked than in living pines, or it may be entirely absent.

Cones and cone scales which could be definitely identified by their internal structure as belonging to the genus are neither numerous nor well preserved; but other specimens, from the appearance of their external characters alone, might be provisionally so referred and thus add to the number of this class of remains. Inasmuch, however, as we have found one type of scale, superficially resembling *Pinus* very closely, in which the internal structure proves it to belong to the Araucarineae, we naturally regard other similar remains as of doubtful generic relationship unless their internal structure is also known.

Well-preserved specimens of wood or lignite were found, both in the Androvette and in the Drummond pit, the best ones in the latter. In some of these amber was found *in situ,* thus demonstrating the source of at least some of this substance occurring in isolated fragments and drops in the lignitic debris. In this connection, however, we may again remark that under the name " amber " we include all of the resinous material found either isolated or *in situ* in any of the lignites, and that it was not exclusively a product of the genus *Pinus.*

Fragments of bark, in all probability belonging to *Pinus*, are among the most striking of the coniferous remains thus far brought to light. Some of the specimens from the Drummond pit, as will be more fully described further on, present the morphological characters of rhytidome, and superficially resemble macerated cycadaceous cones.

Following are more detailed descriptions of some of the best defined remains referable to the genus.

Pinus triphylla sp. nov.

Plate 3, figs. 6, 7[?]; Pl. 22, fig. 1

"Pinus, sp.?" Hollick, Trans. N. Y. Acad. Sci. 12: 31. *pl. 1. f. 20, 22.* 1892. [?]

"Leaf of *Pinus spc.*" Jeffrey, Annals Bot. 22: 215 [descr.], 220 [reference]. *pl. 14. f. 22, 24.* 1908. [?]

Remains consisting of leaves and leaf fascicles. Leaves normally in fascicles of three, the lower part of each fascicle enclosed in a thin membranous sheath.

It appears to be probable that there are at least two triphyllous species represented in our collections, one of which is of much larger dimensions than the other. Figures 6, 7, Pl. 3, probably belong to the larger form and correspond with the section shown in *fig. 24*, in the Annals of Botany, above cited. Figure 1, Pl. 22, belongs to the smaller form and is to be regarded as the type section of the species, with which *fig. 22* in the Annals of Botany may also belong.

Figure 6, Pl. 3, shows the general appearance, natural size, of one of the sheaths, enclosing the basal portion of a triphyllous fascicle, and fig. 7 represents a specimen consisting of a number of leaf fragments, also depicted natural size. It is possible that some or all of these fragments may not belong to the triphyllous species, but they were found closely associated with the specimen represented by fig. 6. These two figures are reproductions of those in the Transactions of the New York Academy of Sciences, above cited, representing the first specimens found at Kreischerville many years ago and described as follows:[15] "Pine needles are distributed plentifully throughout, and in one specimen there is a sheath or bundle, containing *three* needles. Whether this was the normal number or not

[15] Hollick, A. Proc. Nat. Sci. Assoc. Staten Island 1: 31. 1886.

we, of course, cannot say, but it determines one point, namely: that the species was characterized by at least three needles in a sheath—possibly more, but not less."

Figure 1, Pl. 22, shows a transverse section of one of the fascicles, $\times 40$, from the Androvette pit. The needles may be seen to be three in number, enclosed in the remains of the thin membranous sheath, with each needle containing a single bundle. At a higher plane of section each bundle becomes double. This type of short triphyllous fascicle is so constant in its characters, and is so abundantly represented in the lignitic debris of the Androvette pit, that it seems worthy of specific recognition under the name here given to it. By reason of the fragmentary nature of the remains, however, the fact should be borne in mind that in any specimen exhibiting the external characters of three needles enclosed in a sheath, these characters alone, without the corroborative evidence of internal structure, can only be regarded as indicating and not as determining its specific relationship. The positive identification of the species must always depend, primarily, upon the preservation of the specimen being such that the internal structure is clearly defined.

Locality: Old excavation southwest of Killmeyer's hotel, Pl. 3, figs. 6, 7. Collected by Arthur Hollick. Specimens in Mus. Staten Island Assoc. Arts and Sci.

Androvette pit, Pl. 22, fig. 1. Collected by E. C. Jeffrey and Arthur Hollick. Specimen in Jeffrey collection, Cambridge, Mass.

PINUS TETRAPHYLLA Jeffrey

Plate 22, fig. 4

Pinus tetraphylla Jeffrey, Annals Bot. **22**: 214 [descr.], 220 [name]. *pl. 14. f. 17.* 1908.

The remains of this species consist of leaves and leaf fascicles, with the leaves normally in fascicles of four. It is the least common type of short pine shoots thus far found in any of the deposits at Kreischerville. The general characters of the needles are very similar to those of most others of the species of *Pinus* associated with it. The bundle sheath in this species is comparable to that described by Miss M. C. Stopes in the case of certain *Cordaites,*[16] and constitutes one of the numerous pieces of evidence which vouch for the primitive

[16] New Phytologist 2: 91–98. *pl. 9.* 1903.

nature of the genus *Pinus*. A similar sheath is also present in *P. triphylla,* and in the species next described, but in the former it is much less well marked and is scarcely obvious in the low scale of magnification used in the illustration of the characters of that species, shown in fig. 1, Pl. 22.

A transverse section, × 40, through a fascicle of *P. tetraphylla,* is shown in fig. 4, Pl. 22, in which the inner sheath of the transfusion tissue may clearly be seen to pass as a radial stripe through the four foliar traces, separating each of them into two bundles such as are universally found in the hard pines.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimen in Jeffrey collection, Cambridge, Mass.

Pinus quinquefolia sp. nov.

Plate 22, fig. 2

Remains consisting of leaves and leaf fascicles. Leaves normally in fascicles of five, enclosed below in a membranous sheath and with two fibrovascular bundles in each leaf. Transfusion tissue presenting the same characters as in *P. tetraphylla.*

The brachyblasts of this species are much stouter than those of *P. triphylla.* They present the same fragmentary condition of preservation, but the remains are less abundantly represented in the material from the Androvette pit. Figure 2, Pl. 22, shows the characters of *P. quinquefolia* as they appear in a transverse section of a fascicle, × 40. The sheath is only partially present.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimen in Jeffrey collection, Cambridge, Mass.

Cone Scales of Pinus sp.

Plate 9, figs. 11, 12; Pl. 23, fig. 6

A few cone scales of *Pinus* have been found in the macerated material from the Androvette pit. Most of these are in a very bad condition of preservation, which does not make easy a clear interpretation of either their internal or external features of structure.

In figs. 11, 12, Pl. 9, are shown the upper and lower surfaces respectively of one typical cone scale, × 10. The inferior view of the scale shows the presence of a well marked apophysis and a median umbo. The superior aspect of the scale is so well preserved by par-

tial charring that the impress of the wings of the two seeds may still be made out. The superficial features of isolated cone scales of *Pinus,* in view of the great similarity of cone scales of not very closely related species among living pines, can scarcely have more than a generic significance, so we have refrained from giving any specific name to the type of scale depicted in our figures. It is probable, in view of the presence of several diverse types of short shoots in the Kreischerville deposits, that a somewhat similar type of cone scale may have characterized several different species of these pines.

Figure 6, Pl. 23, shows the general features of internal structure present in a transverse section of such a cone scale, $\times$ 40. There is a single series of bundles present, with the xylem lowermost, as is the case in living pines. One of the bundles appears in the center of the figure. The fibrovascular strand further resembles those found in the ovuliferous scales of living pines, in the very sparing development of transfusion tissue. In this respect, both in living and in Cretaceous pines, there is a marked contrast between the reproductive and vegetative leaves, since in both extant and extinct pines transfusion tissue is very strikingly present in the foliage, although absent or confined to the flanks of the bundles in the case of the sporophylls.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Bark of Pinus sp.?

Plate 3, fig. 8; Pl. 22, fig. 5

Feistmantelia Ward, Nineteenth Ann. Rept. U. S. Geol. Surv., 1897–98, Pt. II: 693. 1899.

Quite common among the coarser plant remains found in the Drummond pit are pieces of coniferous bark, characterized by the scaly structure which is found in the case of rhytidomes; and as we have found similar bark in actual connection with Cretaceous pityoxyla elsewhere we are disposed to consider it as probably belonging to some species of *Pinus.*

This material is unquestionably identical with that to which Dr. Lester F. Ward gave the generic name of *Feistmantelia,* the probable nature and affinities of which he discusses at some length in a

note on pp. 694–696 (*l. c.*), regarding it as substantially identical with Feistmantel's "Portion of a stem of a coniferous plant,"[17] and comparing it with the genera *Clathraria, Omphalomela, Cycadeomyelon,* etc., of other authors. Dr. Ward's discussion should be read by all who may be interested in learning the wide range of opinion which has been expressed in relation to this and apparently similar material. Whatever may be thought, however, of the generic identity of our specimens with the remains included in the above mentioned genera by foreign authors, there can scarcely be any doubt that the two species of *Feistmantelia* from the Cretaceous of the United States[18] belong in the same category with our material from Kreischerville and definitely relegate all to the Coniferales and probably to the genus *Pinus.*

Figure 8, Pl. 3, shows a fragment of one of our pieces, natural size, which superficially may be seen to somewhat resemble a dismembered cycadaceous cone.

Figure 5, Pl. 22, gives a sufficient illustration of the internal structure of such remains in transverse section, × 15. They consist of a ground substance which appears to be phloem tissues, although its state of preservation does not make it possible to speak with entire certainty on this point, interlaced with a network composed of sheets of periderm. The periderm tissues may be seen with particular clearness in this figure as meandering, almost homogeneous ribbands, which, with attentive examination, may be seen to present a transverse striation corresponding to the rows of phellem cells. In longitudinal section the same sort of peridermic meshwork is present, but the meshes are somewhat more elongated. The larger fragments very readily break up along the lines of the zones of periderm and fall into small oval pieces, which in an isolated condition have very much the appearance of seeds, thus presenting in mass the resemblance to a cycad cone, as previously noted.

Locality: Drummond pit. Collected by E. C. Jeffrey and Arthur Hollick. Plate 3, fig. 8, specimen in Mus. Staten Island Assoc. Arts and Sci. Plate 22, fig. 5, specimen in Jeffrey collection, Cambridge, Mass.

[17] Mem. Geol. Surv. India, Ser. XI[1] (Jurassic (Oölitic) Fl. Kach): 61. *pl. 10. f. 2.* 1876.

[18] *F. oblonga* Ward, 19th Ann. Rept. U. S. Geol. Surv., 1897–98, Pt. II: 693. *pl. 169. f. 19.* 1899.

F. virginica Font.; Ward, Monog. U. S. Geol. Surv. 48[1] (Status Mesoz. Fl. U. S., second paper): 484; ibid. 48[2]: *pl. 107. f. 3.*

Genus PREPINUS Jeffrey

PREPINUS STATENENSIS Jeffrey

Plate 9, figs. 9, 10; Pl. 22, fig. 3; Pl. 23, fig. 5; Pl. 24, fig. 1

Prepinus statenensis Jeffrey, Annals Bot. 22: 207–214 [descr.], 209 [name]. *pl. 13. f. 1–15.* 1908.

The remains which represent this interesting gymnosperm consist of short shoots bearing numerous needles enclosed in a sheath composed of comparatively short scales or bracts. These shoots were found rather sparingly in the material from the Androvette pit.

Figures 9, 10, Pl. 9, show the well-marked external features, × 10. Above the sheaths are inserted the needles, which are present in an indefinite, large number, and are not verticillate. In this feature they present a contrast to the brachyblasts of all living pines. In cross-section the needles vary from triangular to somewhat polygonal, the latter condition being present in the more internal ones. The appearance of these short shoots is such that at first sight one is tempted to consider them the ends of leafy twigs, bearing primary leaves. Their internal organization, however, clearly shows that they are really short shoots of an apparently primitive type. They may be compared with the shoots described and figured by Fontaine from the Potomac formation and referred by him to Heer's Jurassic genus *Leptostrobus*.[19] Our specimens are much better defined, however, than those indicated in Fontaine's figures, although they are somewhat more fragmentary on account of the condition of charring which is present in so much of our material. They may also be compared with Seward's *Pinites Solmsi* from the Wealden of Ecclesbourne.[20] In fig. 10 may be seen the rhombic scars left by the fall of certain of the basal leaves of the sheath. Usually the scales composing the sheath are all present. We have, unfortunately, not found the branches by which these interesting short shoots were borne. There can be no doubt, however, as to the close relationship of these remains with the genus *Pinus*.

In fig. 3, Pl. 22, is shown a transverse section through a part of a

[19] Monog. U. S. Geol. Surv. 15^1 (Potomac or Younger Mesoz. Fl.): 228; ibid. 15^2: *pl. 101. f. 2, 3; pl 102. f. 1–4; pl. 103. f. 6–12; pl. 104.* f. *6* (=*L. longifolius* Font.). —Ibid. 230. *pl. 101. f. 4; pl. 103. f. 5; pl. 104. f. 1* (=*L. foliosus* Font.).

[20] Cat. Mesoz. Plants, Dept. Geol., Brit. Mus. (The Wealden Flora, Pt. II, Gymnospermæ), 196. *pl. 18. f. 2.*

fascicle of needles, × 10. Along the upper border of the figure appears the axis of the short shoot, showing that a considerable number of the leaves are absent. There must have been twenty or more of these in the fascicle of this species. The details of structure are not well shown in this figure, since the preservation is not entirely satisfactory.

Figure 1, Pl. 24, shows a transverse section through the base of a short shoot, × 18. The wood and phloem are both well preserved in this region and surround an unusually large pith, in which are islands of sclerenchyma such as are found in certain living pines. Resin canals may be seen on the inner side of the xylem.

Figure 5, Pl. 23, shows a portion of fig. 1, Pl. 24, magnified × 180. On the lower side of the figure appears a resin canal filled with tyloses, which supplies good evidence that we have here to do with the axis of a deciduous short shoot and not with a relatively main branch, since tyloses could scarcely be present in an ordinary branch showing a single annual ring. Similar tyloses have been observed in the resin canals of the bracts constituting the sheaths and also in the needles attached to the ends of the brachyblasts. Such conditions could only be normally present in short shoots which had already fallen or were about to separate from the axis.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus PITYOXYLON Kraus

PITYOXYLON STATENENSE Jeffrey and Chrysler

Plate 23, figs. 1–4

Pityoxylon statenense Jeffrey and Chrysler, Bot. Gaz. 42: 8. *pl. 1. f. 1–6; pl. 7. f. 7.* 1906.

The nature and character of the *Pityoxyla* or fossil pine woods found at Kreischerville were described in the paper above cited, and nothing further needs to be added to the general discussion of the subject at the present time. One special feature, however, calls for attention here, viz., the relation of the *Pityoxyla* to the amber found so abundantly in the Androvette pit.

If the view of the provenance of amber taken by Conwentz[21] be

[21] Monographie der Baltischen Bernsteinbaume, p. 5.

adopted, it follows that only the actual occurrence of the substance in organic connection with coniferous remains can constitute good evidence as to the origin of such amber. A great deal of this material from Kreischerville is in all probability bark amber, and constitutes the indurated remains of the resin, which once flowed in the cortical tissues of extinct conifers; but it is not generally possible to definitely connect such amber with its coniferous source. Fortunately, however, in some of the Kreischerville material amber was actually found *in situ* in fragments of lignites, and, *in all such cases which we have had the opportunity to examine, the correlated wood was found to belong to Pityoxylon statenense.* It is not improbable, however, as has been suggested by Conwentz in the case of the Baltic amber, that the same type of *Pityoxylon* may have represented the wood of several different species of pines.

In fig. 1, Pl. 23, is shown a succiniferous fragment in transverse section, × 10, from the Drummond pit. The amber cavity appears along the upper margin of the figure and is clothed with the same abnormal lining of parenchyma as has been described by various authors who have written on the Tertiary amber of the Baltic region. The numerous light spots over the surface of the figure indicate the presence of more or less normal resin canals, similar to those found in the wood of living species of pines. In fig. 2, Pl. 23, is shown another view of the same type of succiniferous *Pityoxylon,* likewise in transverse section, × 10. The amber cavity appears in this instance in the upper left-hand region of the figure. Figure 3, Pl. 23, represents the lining of a part of the amber cavity, × 20. It may be noted that there is present a thick jacket of traumatic parenchyma, quite similar to that described by Goeppert, Conwentz and others in the case of the succiniferous woods of the Baltic deposits. Similar cavities, as is well known, occur as a pathological feature of the wood of living pines. Figure 4, Pl. 23, shows another transverse section, × 40, of the structure of a well preserved fragment of apparently the same species of *Pityoxylon.* Normal resin canals of the vertical type are present in numbers, while a single horizontal canal may be distinguished.

As has been pointed out in the paper on Cretaceous *Pityoxyla* above cited, the fossil pine woods of the Kreischerville deposits differ from living pines in the absence of the marginal tracheids from the medullary rays. Since this marked feature occurs also in the cones

of the pines of the present day, in company with other presumably archaic features, it may be safely assumed that in the case of the *Pityoxyla* producing the amber of the Kreischerville deposits, in so far as it is wood amber, we have to do with an ancestral feature of structure.

Locality: Drummond pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

ARAUCARINEAE

Genus **ANDROVETTIA** gen. nov.

Androvettia statenensis sp. nov.

Plate 3, figs. 1–5; Pl. 7, figs. 1–8; Pl. 8, figs. 1, 2; Pl. 28, figs. 5–8; Pl. 29, figs. 1–6

Remains superficially resembling fragments of fern fronds; margins irregularly lobed or incised; nervation pinnate, craspedodrome, consisting of a well-defined main vein or midrib and simple or forked secondaries, which leave the midrib at acute angles, ascending or gradually diverging and for the most part bent upward and outward toward the margins.

Frond-like fragments consisting of relatively thick tissues and bearing numerous stomata and minute scale-like leaves attached to the surfaces and margins; male aments (?) axillary in the leaves of short flattened lateral shoots or branches which are axillary to lateral leaves of the main shoot and are covered with decussately opposite leaf pairs.

The general appearance of some of the larger fragments from the clay layers may be seen in figs. 1–5, Pl. 3. These are reproduced natural size and the striking resemblance to a fern is apparent; in fact they probably would have been so regarded had the internal structure not been determined. Interesting comparisons may also be made with figures of certain remains of more or less problematic relationship from the Potomac formation.[22] Taking everything into consideration these remains constitute the most remarkable that we have obtained from the Kreischerville deposits, presenting as they do a strong superficial resemblance to ferns and to the modern podocarpous genus *Phyllocladus,* and at the same time to the Cretaceous genera, *Thinnfeldia, Moriconia* and *Thuites.* Their sub-

[22] *Ctenopteris insignis* Font.?, Ward, Monog. U. S. Geol. Surv. 48[2] (Status Mesoz. Fl. U. S.): *pl. 112. f. 7; Zamiopsis insignis* Font., ibid. *pl. 113. f. 4, 5; Thinnfeldia marylandica* Font., ibid. *pl. 114. f. 8, 9; Celastrophyllum? marylandicum* Font., ibid. *pl. 116. f. 7; Plantaginopsis marylandica* Font., ibid. *pl. 117. f. 7.*

stance was evidently quite thick and apparently coriaceous in texture, as it is almost invariably well preserved and may be removed from the clay or separated from the other debris in the form of dark brown or yellowish carbonaceous films.

Figure 1, Pl. 7, shows one of the phylloclads of this species, × 7, which has been bleached by prolonged sojourn in chlorine water, so as to show at the same time its external appearance and internal venation. The margins present dentate projections, which in some cases are leaves and in others very much reduced leafy branches. A central stouter vein runs through the phylloclad from end to end, giving off vascular strands to the right and left. In two instances leaves may be seen attached to the flat surface, a feature which clearly distinguishes our species from *Thinnfeldia* on one hand and from most of the living species of *Phyllocladus* on the other. Figure 2, Pl. 7, shows the base of a phylloclad, × 10, and fig. 3, Pl. 7, shows a somewhat larger specimen, × 6, in which one of the leaves on the flat surface of the phylloclad is very well developed. Another leaf, which is less obvious, appears on the left at a slightly higher level. It is a notable fact that by turning over these phylloclads one can observe on the opposite flat surface leaves corresponding in position, *i. e.,* opposite to those appearing in the figures. A rather less marked opposition of the leaves may be made out on the margins. Figure 4, Pl. 7, shows a phylloclad, or, more accurately speaking, a part of a phylloclad, similar to those described above, × 9, which bears on its sides two leafy flattened branches resembling the habit of *Moriconia.* These are axillary to lateral leaves of the main shoot, as may be distinguished on the uninjured left side of the phylloclad. The *Moriconia*-like lateral branches are covered with decussately opposite leaf pairs, which resemble those of the living *Thuja* and the fossil *Moriconia,* both in their disposition and in the strong flattening of the leafy axis. They also resemble the ultimate branches of *Phyllocladus trichomanioides* Don. In fig. 5, Pl. 7, is shown another phylloclad, × 8, with a leafy shoot still attached to its side, which bears in the axils of its lateral leaves what appear to be immature male cones or aments.

Figure 1, Pl. 8, shows a fragment of what was evidently a large specimen, × 7, and fig. 2, Pl. 8, a similar one, × 8. In both of these figures leaves may be seen attached to the flat surface of the phylloclads in the manner characteristic of the species. Figure 2

presents somewhat intermediate conditions between the phylloclad and the flattened leafy lateral branch, for it is at once markedly phylloclad-like and at the same time shows several leaves attached to the flat surface. Figures 6, 7, 8, Pl. 7, show the characters of the flattened lateral leafy branches, × 7, as they appear when detached from their axes. This remarkable genus is apparently not referable to any fossil plant heretofore described and, moreover, entirely differs in its internal structure, as we shall show presently, from the living genus *Phyllocladus,* so that it is not permissible either on the one hand to refer it to the somewhat vague Cretaceous genus *Thinnfeldia,* or on the other to the equally problematic *Protophyllocladus.*

Turning our attention now to the internal structure of this remarkable fossil plant, we have in fig. 5, Pl. 28, a general view of a transverse section through one of the phylloclads, × 10. There is evidence in the form of woody cylinders of the presence of three branches in the substance of the flat axis. The most central of these is the largest, while the uppermost is the smallest. The narrow wings of tissue stretching on either side of the woody cylinders constitutes the lamina of the phylloclad, in which lie the traces of two or three leaves. The magnification, however, is not great enough to show these. It is not easy to recognize any assimilatory tissue in the lamina on account of the very dark conditions of the cells which compose it. Regarded superficially the lamina is covered with numerous stomata, which are surrounded, in addition to the guard cells, by four or five accessory cells. The presence of these accessory cells does not appear to be of much importance in tracing relationships with other conifers in which the surface characters have been described, since the presence of accessory cells is a very common feature in plants of various affinities, which have the xerophytic habit. Figure 8, Pl. 28, shows a transverse section, × 40, through the base of one of the phylloclads. There is a single woody cylinder present in this case, which is winged above and below. We have not found any stems belonging to the species which are without these laminar wings, even in their lowest portion. In the pith may be seen sclerotic cells, similar to those occurring in *Brachyphyllum* and *Geinitzia.* We have not observed sclerotic tissues in the cortex of the species under discussion. Leaf-traces may be seen on either side of the central cylinder and in the substance of the lateral wings. Figure 7, Pl. 28, shows a transverse section, × 20, through the blade of another

phylloclad, somewhat larger in size than that shown in fig. 5. There are also three woody cylinders present, the central one of which is again the largest. Figure 6, Pl. 28, shows, in transverse section, $\times$ 40, one of the leaves on the edge of the same phylloclad as that shown in fig. 7, in the region where it becomes free from the surface of the flattened axis.

Figure 1, Pl. 29, shows a transverse section, $\times$ 30, of the largest stem in our possession. Here, as in fig. 8, Pl. 28, traces of foliar strands may be seen in the lateral wings. Figure 2, Pl. 29, shows the structure, in transverse section, $\times$ 45, of the central cylinder in fig. 7, Pl. 28. The wood is very similar in general appearance in cross-section to that found in the case of *Brachyphyllum, Geinitzia,* etc. Figure 3, Pl. 29, shows the structure of part of the woody cylinder in fig. 1, Pl. 29, $\times$ 180. It may readily be seen that the resin cells, which as a rule are characteristic of the Podocarpineae, to which the living *Phyllocladus* belongs, are absent. Figure 4, Pl. 29, shows the appearance, in longitudinal approximately radial section, $\times$ 180, of the woody cylinder in the same specimen, which furnished fig. 8, Pl. 28. It may be noted that many of the pits are flattened by mutual contact in the manner characteristic of araucarineous woods, but that this feature is not universal, so that the wood is of the type which we propose to describe under a new generic name (see this Memoir, p. 54). Figure 5, Pl. 29, shows a longitudinal section, $\times$ 180, of the branch which furnished figs. 1 and 3, Pl. 29. The same type of wood is present. Figure 6, Pl. 29, shows a small part of the extreme right-hand portion of fig. 5, Pl. 29, $\times$ 500, to illustrate the very typical araucarineous pitting.

It may be seen from the details of external and internal structure that we have in this species a very peculiar type of conifer which presents a marked similarity in superficial habit to the podocarpineous genus *Phyllocladus,* but differs strikingly from the genus in important features of internal structure. There can be no question that in this case we have to do with one of the many peculiar araucarineous types which we find to be so characteristic of the Kreischerville flora. If Professor Seward and others are right in their contention that the genus *Thinnfeldia* is of filicineous affinities, then our genus, which is beyond question coniferous, has nothing to do with *Thinnfeldia,* with which certain somewhat similar remains from the Cretaceous have been considered to belong. Our species, more-

ever, presents certain differences even in external appearance, notable among which is the presence of leaves on the flat surface of the lamina of the phylloclads, which make it impossible to refer it to *Protophyllocladus* Berry,[23] even if the internal structure of the fossils in question did not remove them from any close relationship with the Podocarpineae of the present day. It seems for these reasons necessary to propose a new generic name for these remains, and as we owe much to the kindness and courtesy of the owner of the Androvette pit, it seems a not unfitting recognition to name the new genus in his honor. The specific name is given from its place of discovery, Staten Island.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Plate 3, figs. 1–5, specimens in Mus. Staten Island Assoc. Arts and Sci. Plate 7, figs. 1–8; Pl. 8, figs. 1, 2; Pl. 28, figs. 5–8; Pl. 29, figs. 1–6, specimens in Jeffrey collection, Cambridge, Mass.

Genus **RARITANIA** gen. nov.

Raritania gracilis (Newberry) comb. nov.

Plate 6, figs. 4–7; Pl. 9, figs. 1–4; Pl. 10, figs. 14–17; Pl. 19, figs. 3–6; Pl. 20, fig. 1

Frenelopsis gracilis Newb. Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 59. *pl. 12. f. 1–3a.* 1895.

Our specimens, depicted in figs. 4–7, Pl. 6, are undoubtedly specifically identical with those described under the above name by Newberry from the Cretaceous of New Jersey; but he was clearly at fault in referring the species to the genus *Frenelopsis* Schenk, which is characterized by articulated branches with opposite leaves,[24] whereas in his specimens, as well as in ours, the branches are not articulated and the leaves are as Newberry describes them, "spirally arranged." They are so minute, however, that they are not visible to the unaided eye, and their exact arrangement is difficult to determine satisfactorily from impressions alone, even with the aid of a hand lens. The dichotomously forked branches, together with the minute prickle-like foliar organs, give a superficial appearance almost

[23] Bull. Torrey Club 30: 440. 1903.

[24] *F. Hoheneggeri* (Ettingsh.) Schenk, Paleontogr. 19[1]: 13. *pl. 4. f. 5–7; pl. 5. f. 1, 2; pl. 6. f. 1–6; pl. 7. f. 1.* 1871. (*Culmites priscus* Ettingsh.?, Abh. K. K. Geol. Reichsanst. 1[3]: No. 2, p. 24. *pl. 1. f. 5; pl. 3. f. 4–8; Thuites Hoheneggeri* Ettingsh., ibid. 26. *pl. 1. f. 6, 7.* 1851.)

exactly like that of the living pteridophyte genus *Psilotum,* and it has seemed somewhat strange that Newberry did not recognize this resemblance, especially as he had previously referred another plant with similar habit to the genus.[25]

Figures 4–6, Pl. 6, show the general form and appearance of the species, natural size, and fig. 7, on the same plate, represents a portion of one of the ultimate forking branches, enlarged in order to show the presence of the foliar organs and their appearance under an ordinary hand lens.

In consideration of these facts it is evident that the species cannot properly be included in the genus *Frenelopsis,* and, as we shall indicate further on, the internal structure shows that it is a conifer and not a pteridophyte, we have adopted for it a new generic name, *Raritania,* in order to correlate it with the geological formation of which it is characteristic. It may be pertinent to remark, however, that we expect to demonstrate, in a subsequent memoir, the probability that certain other American Cretaceous plants have been properly referred to the genus *Frenelopsis,* although these are in general gnetoid remains, resembling the living genus *Ephedra*, and consequently not related to the coniferous genus *Frenela*.

The determination of the correct botanical affinities of *Raritania,* in view of the confusion of names and alliances above indicated, was therefore recognized to be a matter of considerable importance, and diligent search was made for specimens which could be subjected to critical examination. The result was the separation of a number of fragmentary leafy twigs from the lignitic debris which almost certainly belong to the genus and in all probability to the particular species under discussion.

Figures 1–4, Pl. 9, represent external views of several of these twigs, × 10, and figs. 14–16, Pl. 10, are views, × 5, of two of the same specimens and one of a cone, attached to a peduncle which has the same type of leaf as the twigs. Unfortunately this cone is very poorly preserved, and it has not been possible to learn anything from its internal structure, either as to its exact botanical affinities or, in the case of the peduncle, as to its relation to the twigs associated with it. Incidentally it may be remarked

[25] ***Psilotum inerme*** Newb. Ann. N. Y. Lyc. Nat. Hist. 9: 38. 1868. (= ***Cabomba inermis*** (Newb.) Hollick, in Newb. Monog. U. S. Geol. Surv. 35 (Later Ext. Fl. N. Amer.): 92. *pl. 22. f. 2; pl. 23. f. 2.* 1898.)

that this cone has much the appearance of those which have been figured in connection with branches of *Inolepis imbricata* Heer,[26] from the Cretaceous of Greenland, but the leaves do not agree, while the external resemblance between the peduncle and the twigs in our specimens is so strong that there can scarcely be any doubt that these are generically if not specifically identical with each other. Figure 17, Pl. 10, shows the same cone, $\times$ 10, and there is enough of the surface sculpturing still remaining to indicate that the scales were spirally arranged and were not, externally at least, divided into two segments, as in the case of the Abietineae.

From the preceding discussion it may be inferred that the results obtained from the studies of the external characters of the specimens were not entirely conclusive either as to their identity with the genus *Raritania* or as to their exact botanical relationship; but, as may be learned from the discussion which follows, the internal structure was found to afford a much more satisfactory field of investigation.

Figure 3, Pl. 19, shows the internal structure, in transverse section, $\times$ 30, of the twig shown in fig. 3, Pl. 9. The woody cylinder is immature and is badly preserved. The cortex is confluent with the decurrent leaf bases and is characterized by the presence of a considerable number of stone cells, which have mostly disappeared in charred specimens like that under discussion, but are more apparent in badly preserved material. There are indications of four leaves on the periphery of the section, each of which shows a more or less apparent resin canal, which exactly subtends the foliar traces. Figure 4, Pl. 19, shows a transverse section, $\times$ 45, of the stouter twig shown in fig. 1, Pl. 9. An attached leaf may be seen on the upper side. It contains a resin canal which communicates with the surface of the stem by means of a crack, a result of the condition of fossilization. On the right is a resin canal in the cortical tissues which marks the position of the decurrent portion of another leaf. On the upper side of the section the tissues of the phloem are partially preserved and these strongly resemble those found in *Geinitzia* (see this Memoir, pp. 40–42). The woody cylinder is remarkably well preserved in this specimen and presents the same general features of microscopic structure as in *Brachyphyllum* (see this Memoir, p. 33); but the pith is relatively smaller than in either of the other two araucarineous types mentioned. Figure

[26] Fl. Foss. Arct. 3 (Kreide-Fl.): 72. *pl. 16. f. 12–16; pl. 23. f. 6c.*

5, Pl. 19, is a view of a longitudinal section, × 20, of a rather badly preserved twig, illustrating the transverse cracks, which are a frequent feature of fossilization in these and other similarly preserved specimens, which feature, as previously suggested by the senior author,[27] led Newberry into the error of referring certain partly decorticated twigs of *Widdringtonites* to *Frenelopsis*,[28] on account of the resemblance of these cracks to joints or articulations. Figure 6, Pl. 19, shows a longitudinal section, × 20, passing through the broken apex of a leaf on the upper surface of another specimen. By the use of a lens sclerites can be made out in the cortex of the upper surface and in the pith (nearly opposite the termination of the leaf).

Figure 1, Pl. 20, is a longitudinal section of the wood, × 500, showing the radial pitting. The pits are fewer in this species than in any other which we have examined, on account no doubt of its extremely xerophytic habit and it is not easy in all sections to find the araucarineous type of pitting. This can, however, generally be observed in the ends of certain of the tracheids, as is shown in the figure last mentioned, in which the pits may be seen to be obviously flattened by mutual pressure in the typical araucarian fashion. We therefore conclude, from the internal structure of the twigs of these remains, that there is no reasonable doubt as to their araucarineous affinities, and if we have correctly identified them as the remains of *Raritania* this determines the correct systematic position of the genus.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Plate 6, figs. 4–7, specimens in Mus. N. Y. Bot. Gard. Plate 9, figs. 1–4; Pl. 10, figs. 14–17; Pl. 19, figs. 3–6; Pl. 20, fig. 1, specimens in Jeffrey collection, Cambridge, Mass.

Genus WIDDRINGTONITES Endlicher

WIDDRINGTONITES REICHII (Ettingshausen) Heer

Plate 5, figs. 1–4; Pl. 8, figs. 7–11; Pl. 20, figs. 3–5

Widdringtonites Reichii (Ettingsh.) Heer, Fl. Foss. Arct. 6^2: 52. *pl. 28. f. 5.* 1882.—Hollick, Monog. U. S. Geol. Surv. 50 (Cret. Fl. S. N. Y. and N. Eng.): 44. *pl. 4. f. 6, 7.* 1906.

[27] Bull. N. Y. Bot. Gard. 3: 411. 1904.

[28] Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 58. *pl. 12. f. 4, 5* (*Frenelopsis Hoheneggeri* (Ettingsh.) Schenk?).

Frenelites Rechii Ettingsh. Kreidefl. Niederschöna 246. *pl. 1. f. 10a–10c.* 1867.—Hollick, Trans. N. Y. Acad. Sci. 12: 29. *pl. 1. f. 23.* 1892.

This is apparently the most abundantly represented of any coniferous species thus far found in the Kreischerville deposits. The remains occur in almost every layer of the plant-bearing beds in the Androvette pit, and relatively large masses of the delicate branchlets, generally more or less matted together, can often be obtained, although well preserved specimens are difficult to isolate from the lignitic debris.

The exact botanical relationship of the genus has never been satisfactorily determined by any of the authorities who have studied and described it, although affinity with *Frenela* and with *Widdringtonia* is inferred by Ettingshausen and Heer respectively, in the generic names which they adopted.

Specimens are represented natural size by figs. 1–3, Pl. 5. Figure 3 is that of a partly decorticated branch, with some of the smaller leafy branchlets attached, and fig. 4, on the same plate, shows a portion of a branchlet as it appears when enlarged under a hand lens, showing the phyllotaxy.

Figures 7–11, Pl. 8, represent views of the external features of small twigs, $\times$ 10, which seem to be referable to this species. These figures resemble very strongly most of the published illustrations of *Widdringtonites*, and since some of our twigs show internal structure it is possible to determine their true botanical relationship.

Figure 3, Pl. 20, is a transverse section, $\times$40, of the specimen shown in fig. 8, Pl. 8. Several of the leaves are included in the figure at different planes of section. On the upper side of the figure one may be seen cut through its region of greatest expansion. On the opposite side a leaf appears as cut through its apex. On the sides of the figure are shown the bases of three other leaves. The xylem cylinder is small and contains a rather narrow pith, in which sclerotic elements are sometimes present, although none of these appears in the plane of the section. Figure 4, Pl. 20, shows a portion of the upper margin of fig. 3, $\times$ 60. It is possible to make out here with some distinctness that a single resin canal is present in the leaf. Near it lies a fibrovascular bundle which is accompanied by dorsally directed borders of transfusion tissue. Figure 5, Pl. 20, shows the radial

structure of the wood in longitudinal section, $\times$ 500. The pitting, when fully established, as it is about the middle of the figure, is obviously araucarineous. If we are right in correlating the specimens with structure preserved, shown in our figs. 3–5, Pl. 20, with *Widdringtonites Reichii,* it follows that this species, in spite of its external resemblance to the section *Widdringtonia* of the cupressineous genus *Callitris,* is in reality another of the many araucarineous conifers which flourished during that portion of the Cretaceous period when the Kreischerville clays were deposited. If these conclusions are justified by the facts, as they appear to be, it is a further proof that external appearances alone constitute a very unsafe guide in the matter of inferring the affinities even of late Mesozoic conifers with those now living. That this view of the matter is reinforced not only by the study of the internal structure of the twigs, but also from a similar study of certain cone scales associated with them, may be appreciated by reference to the facts in connection with remains of this kind elsewhere described in this Memoir.

Locality: Androvette pit. Plate 5, figs. 1–4, collected by Arthur Hollick. Specimens in Mus. Staten Island Assoc. Arts and Sci. Plate 8, figs. 7–11; Pl. 20, figs. 3–5, collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus THUITES Sternberg

THUITES sp.?

Plate 8, figs. 12–18; Pl. 27, figs. 4–6; Pl. 28, figs. 1–4

The new genus *Androvettia* is not the only araucarian with verticillate leaves which has come under our notice from the Androvette deposits. In figs. 12–17, Pl. 8, are shown the surfaces of three twigs, $\times$ 10, in each case represented from the two opposite sides, which have the appearance and the whorled leaves characteristic of the genus *Thuites* as commonly understood, and of the specimen figured by Newberry from the Cretaceous of South Amboy, N. J., under the name *Thuya cretacea* (Heer).[29]

In fig. 2, Pl. 28, the base of the specimen shown in figs. 14, 15, Pl. 8, is shown in transverse section, $\times$ 30. Two opposite leaves may be seen, one on the right and the other on the left of the figure. The plane of section in the opposite direction is not quite accurately trans-

[29] Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 53. *pl. 10. f. 1, 1a.*

verse, so that the base of only one of the leaves of the decussate pair can be made out. Figure 3, Pl. 28, shows a similar section of the same specimen, $\times$ 50, in which the upper and lower leaves are those best developed in the plane of section. In both of these figures there are present abnormal cavities in the substance of the leaves, the exact nature of which cannot be made out. Figure 4, Pl. 28, represents the central portion of fig. 3, $\times$ 100.

It may be noticed that the elements of the fibrovascular cylinder are very immature and somewhat disturbed, as a result of fossilization. It has been found difficult to secure an old enough twig of this species to determine the structure of the secondary wood, although the structure of the leaves makes it very probable that we have here to do with an araucarineous conifer, since the distribution of the transfusion tissue is not lateral to the foliar strands as in *Thuja* and the other Cupressineae, but has the same tendency to surround the phloem of the bundle which has been noted in the other araucarineous twigs previously described. However we are not left entirely to surmise in this case, for in fig. 18, Pl. 8, is shown a young twig, $\times$ 10, with a single pair of verticillate leaves, which is sufficiently mature to make it possible to determine the structure of its wood as araucarineous. In fig. 4, Pl. 27, is shown a transverse section of this fragment, $\times$ 35. On the two surfaces of the figure may be seen furrows, which mark the line of separation of the two leaves. In the center appears the fibrovascular cylinder, in which the wood is well developed. Subtending the ends of the woody cylinder and opposite clear interruptions in its continuity are the traces of the leaves. Figure 5, Pl. 27, represents a transverse section, $\times$ 35, of the opposite and upper end of the same fragment near the level of separation of the tips of the leaves from the surface of the stem. On the lower side of this figure one of the leaf traces may clearly be seen as a dark spot in the substance of the leaf. At this level the traces of the decussate pair of leaves are leaving the central cylinder, as may be perceived by noting the corresponding two deep opposite bays in the woody cylinder. The central cylinder is surrounded as a whole by a dark boundary, which appears with particular clearness in this figure. The nature of this boundary has not been easy to decipher. It is not possible to decide whether it is merely a zone of collapsed sieve tubes, such as often occurs in the conifers, and which we have found in the case of *Brachyphyllum,* or

of a sclerenchymatous sheath. On the whole the former supposition appears more probable. Figure 6, Pl. 27, shows a portion of the section shown in fig. 4, Pl. 27, × 45. The very small wood elements can here be seen somewhat more clearly. There are no resiniferous elements present in the wood of this species and in this respect it resembles most of the Araucarineae described elsewhere in this Memoir. A longitudinal section of the wood, × 500, such as is shown in fig. 1, Pl. 28, makes it clear that here too we have to do with an araucarineous conifer of the same general type as *Brachyphyllum,* for the characteristic type of pitting in the wood is unmistakably present. In all of the examples of conifers with verticillate foliage and araucarineous internal structure, which we have found in the Kreischerville deposits, cortical resin canals are universally absent and in this feature as well as in their verticillate foliage they markedly resemble each other. Since our genus *Androvettia* is certainly an araucarian, and since the same statement is true of the last described fragment and is probably true of the three similar twigs described above, which we have provisionally referred to the genus *Thuites,* it seems likely that other Cretaceous coniferous genera with verticillate leaves, viz., *Moriconia, Inolepis,* etc., are probably araucarineous as well. This probability can, of course, only become a certainty when it becomes possible to investigate the internal structure of the last mentioned genera.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus BRACHYPHYLLUM Brongniart

BRACHYPHYLLUM MACROCARPUM Newberry

Plate 4, figs. 12–14; Pl. 9, figs. 7, 8; Pl. 11, figs. 1, 2, 4, 5; Pl. 12, figs. 1–6; Pl. 13, fig. 1

Brachyphyllum macrocarpum Newb. Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays) : 51, footnote. 1895.—Hollick and Jeffrey, Amer. Nat. 40: 201–203. *pl. 3. f. 1–5; pl. 4. f. 1–6; pl. 5. f. 1–4.* 1906.

Thuites crassus Lesquereux, Rept. U. S. Geol. Surv. Terr. 8 (Cret. and Tert. Fl.) : 32. 1883.

Brachyphyllum crassum (Lesq.) Lesq. Proc. U. S. Nat. Mus. 10: 34. 1887.—Newb. Monog. U. S. Geol. Surv. 26 (Fl. Amboy

Clays): 51. *pl.* 7. *f.* 1–7. 1895. Not *B. crassum* Tennison-Woods, Proc. Linn. Soc. New South Wales 7: 660. 1883.

There can be no question in regard to the identity of our specimens with the species described and figured by Newberry from the Cretaceous of New Jersey, or in regard to their affinities with the Araucarineae, as we have elsewhere shown;[30] but the determination of these facts does not mean that all of the coniferous remains which from time to time have been referred by various writers to the genus *Brachyphyllum* necessarily belong in it, or that all are necessarily araucarineous in their affinities. Our determinations, thus far, must be regarded as limited to the particular species under discussion.

Since the publication of our preliminary paper in the American Naturalist (*l. c.*), however, we have had the opportunity to examine a great deal of additional material, some of it in an admirable condition of preservation, and as a consequence are able to give a much fuller account than that which first appeared.

Detached leaves and fragments of twigs are abundant elements in the lignitic debris of the Androvette pit, but only one large specimen, obtained from the Drummond pit, has thus far been found. This latter is represented, natural size, in fig. 12, Pl. 4. It is partly decorticated, but shows the characteristic method of branching and the club-like shape of the ultimate twigs. Figures 13, 14, Pl. 4, and figs. 7, 8, Pl. 9, represent termini and lower portions of twigs, × 10, showing the phyllotaxy and the closely imbricated, striated, scale-like leaves. It is also probable that some of the coarser lignite fragments with araucarineous structure may be referable to this species, as may be found discussed under the several types of such wood further on.

Figure 1, Pl. 11, presents a general view in transverse section, × 11, of the structure of a well preserved although somewhat flattened stem of *B. macrocarpum*. In the center may be seen the woody cylinder enclosing a rather large pith, which even with the low power of magnification used is seen to be occupied by masses of sclerenchyma. Surrounding the fibrovascular cylinder is a cordon of resin canals, which appear as holes in the photomicrograph. External to these on the upper side of the figure is a dark line which marks a zone of periderm deep under the surface of the stem. Still

[30] Amer. Nat. 40: 189–215. *pls. 1–5.* 1906.

further out are other resin canals belonging to the adnate leaves. The periphery of the section has a somewhat mottled appearance, which is due to the presence of strands of sclerenchyma just underneath the epidermis. The fact that the leaves are free from the surface of the stem merely by a narrow margin may be seen by following the outline of the section. Figure 2, Pl. 11, shows a similar section, × 28, of a much younger and smaller stem than that which appears in fig. 1. On the margin of the section may be seen the indications of three leaves. The distribution of resin canals is the same as in fig. 1, but is less easily made out. The central cylinder is so small that it can scarcely be seen without magnification by means of a lens. Figure 4, Pl. 11, is the central cylinder and immediately surrounding tissues, × 15, of the section shown in fig. 1. Figure 5, Pl. 11, shows the central cylinder of the same specimen in longitudinal section, × 15. In this view the fact that the sclerenchyma occurs in nests may clearly be made out.

Figure 1, Pl. 12, is a part of the section shown in fig. 4, Pl. 11, × 40. In the upper part of the field may be seen a mass of cortical sclerenchyma. Below this the cortex is occupied by two resin canals. Inferior to the line joining these lies the phloem, which, as was pointed out in the preliminary article, contains none of the bast fibers characteristic of the Sequoiineae, with which *Brachyphyllum* has been placed by most authors, on account of its general external appearance. The phloem terminates above in a discontinuous dark line, which is constituted by masses of collapsed sieve-tubes similar to those which occur in many living conifers. Below the phloem is the xylem, which presents the illusory appearance of two annual rings, due to inequality in growth. The inner part of the xylem is very badly preserved and only occasionally shows the presence of the protoxylem clusters, which exhibit, however, no features of special interest. Internal to the wood is the pith, consisting of thin-walled parenchyma and islands of sclerenchyma, one of which appears in the field. Figure 2, Pl. 12, is a view of another part of the section shown in fig. 4, Pl. 11, × 40. On the upper left-hand may be seen the layer of deep periderm which has been mentioned above. On the extreme left, just outside the phloem, a leaf trace may be seen on its way outward. It has not yet undergone the divisions which characterize it in its more external course. Figure 3, Pl. 12, is a portion of the same section, × 180,

showing the wall of the central cylinder. The xylem may be seen to be made up of tracheids, without any admixture of parenchymatous elements. External to it is the phloem, separated from it by a slight interval, due to decay. Figure 4, Pl. 12, is a similar section, × 40, in which may be seen a forking leaf trace. In *Brachyphyllum* the foliar trace divides in the outer cortex or in the mesophyll of the leaf into a large number of very fine strands, which finally become lost in a continuous band of transfusion tissue which occurs underneath the palisade parenchyma of the leaf. Figure 6, Pl. 12, shows this transfusion tissue in transverse section, × 180. It appears as a stripe of tracheary cells running across the center of the field from side to side. Figure 5, Pl. 12, illustrates the character of the tissues in the vicinity of the epidermis, as they appear in transverse section, × 40. The dark masses just beneath the epidermis are the strands of fibrous tissue which are partly responsible for the striated appearance of the leaves of *Brachyphyllum* in well-preserved impressions. The striations stand out most clearly in partially decayed material, which throws the sclerotic ridges into stronger relief. There is, however, a finer striation, which appears even in well-carbonized material, due to the presence of rows of depressed stomata.

Figure 1, Pl. 13, shows the structure of the central cylinder of a very young branch of *Brachyphyllum macrocarpum*, in transverse section, × 40. Several fibrovascular bundles are present which have not as yet been united with each other by the formation of a continuous woody cylinder such as is found in the older stem. On the right of the figure may be seen a leaf trace making its way outwards into the cortex. It subtends a clearly marked gap in the central cylinder. The anatomical fact represented by this figure makes it difficult to accept the hypothesis that the araucarineous conifers have a close relation to the Lycopodineae, an hypothesis recently revived with some force of argument by Seward,[31] but it has been pointed out by the junior author[32] that none of the Lycopodineae, living or extinct, have foliar gaps, while in the Araucarineae, both living and extinct, foliar gaps, so far as our knowledge goes, are always present. In our investigations we have had the opportunity to examine this feature in a number of hitherto structurally unknown Araucarians, which show every indication of representing an older type than those

[31] Philos. Trans. Roy. Soc. London B 198: 305–411. *pls. 23, 24.* 1906.
[32] Philos. Trans. Roy. Soc. London B 195: 119–146. *pls. 1–6.* 1902.

now living. Foliar gaps have been observed to be invariably present in all these cases. This is one of the many features which make it very difficult to accept the hypothesis of the lycopodineous origin of the Coniferales, and other equally cogent reasons for rejecting this hypothesis will be discussed further on.

Locality: Drummond pit. Plate 4, fig. 12, collected by John M. Dunnigan. Specimen in Mus. Staten Island Assoc. Arts and Sci.

Androvette pit. Plate 4, figs. 13, 14; Pl. 9, figs. 7, 8; Pl. 11, figs. 1, 2, 4, 5; Pl. 12, figs. 1–6; Pl. 13, fig. 1, collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Cone of BRACHYPHYLLUM sp.?

Plate 9, figs. 5, 6; Pl. 11, fig. 3; Pl. 14, fig. 3

A single fragmentary cone, × 10, viewed from opposite sides, is shown in figs. 5, 6, Pl. 9. It was apparently ellipsoidal in shape. The upper part is only represented by the denuded axis, somewhat flattened, which was doubtless originally covered with scales similar to those yet attached to the lower part. These scales are strikingly like the leaves which cover the branches of *Brachyphyllum* and the relationship of the cone to that genus would naturally be inferred from these external characters alone, although it may be seen that the scales are somewhat less broad than the leaves on the shoots, represented by figs. 7, 8, on the same plate, and they may not belong to the same species.

Figure 3, Pl. 11, shows a transverse section, × 10, through the peduncle or lower part of this cone, and the general features may be seen to be almost identical with those of the stem of *Brachyphyllum macrocarpum* shown in figs. 1 and 2, on the same plate, thus making probable at least the generic relationship.

Figure 3, Pl. 14, shows a transverse section, × 35, through the axis. On the left side of this figure may be seen a break in the surface of the cone. The cortical tissues of the axis are occupied by very numerous resin canals. Inside the resin canals lie very small fibrovascular strands, which can scarcely be seen with the degree of magnification used in this case. The center of the axis is occupied by a large pith which is free from stone cells, although these are abundant in the pith of the peduncle, as may be made out in fig. 3, Pl. 11.

It is unfortunate that in no instance have we found the cones and branches attached, but other investigators have also suffered the same disappointment. Thus Newberry remarks:[33] "Unfortunately, none of the specimens establish beyond all doubt the connection between the cones and the branches, but some of the cones are borne on pedicels which are marked with scales essentially like those of the branches under consideration [*B. macrocarpum*]." The cones figured by Newberry (*l. c., pl. 7, figs. 3, 4, 6*) are too imperfect for comparison with ours, but his *fig. 3* has a striking resemblance to the cone described and figured by Velenovsky under the name *Pinus protopicea*,[34] from the Cretaceous deposits of Bohemia, where *Brachyphyllum* likewise occurs, and the latter author also figures a basal portion of one of these cones (*l. c., fig. 12*) showing scales somewhat suggestive of ours; but all of the above mentioned figures represent specimens which are much larger. A cone found in the Drummond pit, depicted in fig. 10, Pl. 3, and described on p. 68 of this Memoir, should be incidentally mentioned here, as may be understood by reference to the discussion in connection with it.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus GEINITZIA Endlicher

Geinitzia Reichenbachi (Geinitz) comb. nov.

Plate 5, figs. 7–10; Pl. 8, figs. 3, 4; Pl. 16, figs. 2–4; Pl. 17, figs. 1–4; Pl. 18, figs. 1–4

Araucarites Reichenbachi Gein. Charakter. Schichten u. Petref. Sächs.-Böhm. Kreidegeb. 3: 98. *pl. 24. f. 4.* 1842.

Geinitzia cretacea Endl. Synops. Conif. 281. 1847.

Sequoia Reichenbachi (Gein.) Heer, Fl. Foss. Arct. 1: 83. *pl. 43. f. 1d, 2b, 5a, 5d, 5dd, 8, 8b.* 1868.—Hollick, Monog. U. S. Geol. Surv. 50 (Cret. Fl. S. N. Y. and N. Eng.): 42. *pl. 3. f. 4, 5.* 1906.

"*Sequoia Couttsiæ*, Heer." Hollick, Trans. N. Y. Acad. Sci. 12: 30. *pl. 1. f. 5.* 1892.

The specimens which we have figured and included under the above name are unquestionably identical with most of the fossil coniferous

[33] Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 52.

[34] Gymnosp. Böhm. Kreidef., 31. *pl. 7. f. 4.*

remains commonly referred to *Sequoia Reichenbachi.* In both the clay layers and the lignitic debris of the Androvette pit the leafy twigs of this species are the most abundant of the many so-called *Sequoia* fragments; but examination of their internal structure has demonstrated that they do not belong to that genus, as will be subsequently described, and hence the generally accepted generic name must be abandoned.

The species is also clearly not referable to the genus *Araucarites* as defined by either Sternberg[35] or Endlicher,[36] but belongs in the genus *Geinitzia* of the latter author, in which he included it under the name *Geinitzia cretacea,*[37] ignoring the earlier specific name given by Geinitz. In view of the above mentioned facts and in accordance with the accepted rules of nomenclature, we have therefore adopted for the name of this species the new combination *Geinitzia Reichenbachi* (Gein.).

The general appearance of the leafy twigs, natural size, as they occur in the clay layers, is well indicated in figs. 7–10, Pl. 5, and the details of the external characters in the enlargements shown in figs. 3, 4, Pl. 8. These latter two figures represent a single specimen, × 10, viewed from opposite sides, and they show both the falcate form of the leaves and their tetragonal cross-section.

It will probably be conceded by paleobotanists that our figures serve to identify the specimens with the species beyond any reasonable doubt; but the fact should be borne in mind that different authorities have included a number of more or less different forms under it, some of which may have been referred to the original species incorrectly, and this has perhaps resulted in crediting it with an erroneous and altogether too extended geographic and stratigraphic range. As commonly recognized its geographical distribution covered the United States, Canada, Greenland and Europe, while stratigraphically it apparently extended from the upper Jurassic to the end of the Cretaceous period. We, therefore, desire to have it understood that the facts of internal structure and the conclusions in regard to botanical relationship which are next described and discussed are referable only to the species as it occurs in the Cretaceous deposits at Kreischerville or in their equivalents elsewhere.

[35] Presl, in Sternb., Verst. 2: 203. 1838.
[36] Gen. Plant. 263. 1836–40.
[37] Synops. Conif. 281. 1847.

Figure 2, Pl. 16, shows a general transverse section, × 30, of the leafy twig just referred to. The bases of two leaves may be distinctly made out, one on the left and the other on the right of the figure. There are less clear indications of the bases of three other leaves on the remaining portion of the periphery. In the center of the stem lies the woody cylinder, which encloses a larger pith than is found in the case of the living *Sequoia gigantea* Torr. The pith which occupies the center of the figure is largely taken up by stone cells, which appear dark on account of the thickness of their walls. Figure 3, Pl. 16, shows a longitudinal section of the same twig, × 30. The pith is well preserved but the tissues of the central cylinder are less perfectly represented. On the right and left certain irregularities of contour mark the bases of leaves. Figure 4, Pl. 16, is a transverse section of a leaf, × 40. Three resin canals may be seen, a median large one and two smaller lateral ones. The magnification is not sufficient to show that the transfusion tissue, which is abundantly present, bends outward from the flanks of the bundle and tends to envelop the resin canals, thus presenting a marked contrast to the transfusional borders of the foliar strands in *Sequoia,* which are directed towards the sides and not towards the dorsal surface of the leaf.

Figures 1, 2, Pl. 17, show other transverse sections of the same twig, × 28. In fig. 2 may be seen on the upper side a foliar gap in the woody cylinder, which subtends an outgoing leaf trace. Figures 3, 4, Pl. 17, show other similar sections of the same twig, × 40. These somewhat numerous figures are introduced in order to give as complete an idea as possible of the structure of this important Cretaceous fossil, which is now for the first time studied from the standpoint of internal structure.

Figure 1, Pl. 18, shows, in longitudinal section, × 40, the composition of the pith in the same twig. It is largely occupied by stone cells such as do not occur in either of the living species of *Sequoia,* but are common in the pith of *Brachyphyllum.* The wall of the stone cells is strikingly laminated from the action of the charring process, to which is due the preservation of most of the Cretaceous material from Kreischerville. This lamination is accompanied by a considerable swelling of the cell. It is only sclerenchymatous elements which are affected in this way, tracheids, for example, not being noticeably influenced by heat. In branches which are less charred

and less well preserved, the tracheary tissues have suffered greatly from decay, while the stone cells are much better preserved than they are in the material illustrated in our figures. This swelling up and lamination of sclerenchyma makes it necessary, in many cases, to study the structure of both badly and well preserved branches which present the anatomical peculiarities of *Brachyphyllum macrocarpum* and *Geinitzia Reichenbachi*. Figure 2, Pl. 18, shows a transverse section of the wood, $\times$ 180. It may be noticed that the resin cells, which are so characteristic of the wood of the living species of *Sequoia,* are quite absent in this case. Figure 3, Pl. 18, shows a longitudinal section of the wood, $\times$ 500, in which the pitting it obviously araucarineous. Figure 4, Pl. 18, shows another similar section, under the same degree of magnification, with alternating pits. In the tracheid to the right of that containing these pits may be seen a single row of pits, some of which are in contact and others show a round contour. We have in fact in this wood the same type of structure that is found in *Brachyphyllum,* as described on p. 35 of this Memoir. In the case of the remains commonly called *Sequoia Reichenbachi* we have accordingly to do, not with a species belonging to the modern genus *Sequoia,* but with one of araucarineous affinities, and this instance is another of the many in which we have learned the futility of attempting to definitely refer Mesozoic leafy twigs to genera still living on the sole basis of external habit. In this connection it is interesting to recall that Schimper[38] expressed his ideas in regard to the probable relationship of the Cretaceous so-called *Sequoias* in the following words: "*Les espèces de l'epoque crétacée reproduisent par leurs feuilles tétragones courbées en faux l'aspect des Araucaria, avec lesquels élles ont été quelquefois confondues. Elles pourraient bien former un genre particulier.*"

Locality: Androvette pit. Plate 5, figs. 7, 8, 10, collected by Arthur Hollick. Plate 5, fig. 9, collected by William T. Davis. Figures 7, 9, specimens in Mus. Staten Island Assoc. Arts and Sci.; figs. 8, 10, specimens in Mus. N. Y. Bot. Gard.

Plate 8, figs. 3, 4; Pl. 16, figs. 2–4; Pl. 17, figs. 1–4; Pl. 18, figs. 1–4, collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

[38] Palaeont. Veg. 2: 314.

Geinitzia sp.

Plate 8, figs. 5, 6; Pl. 18, figs. 5, 6; Pl. 19, figs. 1, 2

In figs. 5, 6, Pl. 8, are shown opposite sides of a leafy twig, × 10, which has a close resemblance to the species last described, although the leaves may be seen to be more slender and less closely arranged on the twig. We have been unable to definitely refer this specimen to any one of the so-called *Sequoia* species, although it is suggestive of certain forms of *S. subulata* Heer, from the Cretaceous of Greenland,[39] and some others of the closely allied Cretaceous species, with one or another of which it may ultimately be proved to be identical. The internal structure, however, shows it to be so closely allied to *G. Reichenbachi* that no matter how it may be referred it cannot possibly be regarded as a *Sequoia,* but should be included in the genus *Geinitzia.*

Figure 5, Pl. 18, shows a transverse section of this specimen, × 40. The stem is much slenderer than is the case in the average branches of *G. Reichenbachi,* but it presents the same general features of structure. The leaves in the specimen under discussion, however, contain but a single resin canal. Figure 6, Pl. 18, shows a somewhat larger and better preserved specimen of apparently the same species, in transverse section, × 25. The leaf has the same single resin duct. In the pith may be made out stone cells similar to those found in *G. Reichenbachi.*

Figure 1, Pl. 19, shows the structure of the wood and phloem, as seen in transverse section, × 150. The wood is without resin cells, as in *G. Reichenbachi.* The phloem is well preserved and shows general features such as are found in all those araucarians of which *Brachyphyllum* and *Geinitzia* may stand as types. Figure 2, Pl. 19, shows a longitudinal approximately radial section of the wood of this species, × 180. In a single tracheid the pits are flattened by mutual contact, while in the others they are generally round. There can be no doubt that in this species also we have to do with an araucarineous and not with a sequoiineous conifer, and have further evidence which confirms the suspicion that other, if not all of the so-called *Sequoias* from the Cretaceous do not belong to that genus but to some genus or genera which represent a peculiar and probably extinct type of vegetation.

[39] Fl. Foss. Arct. 3 (Kreide-Fl.): 102. *pl. 27. f. 3b, 7a, 7b, 8b, 8c, 15a; pl. 28. f. 3–6b; pl. 29. f. 2c, 7b; pl. 34. f. 1a, 1b.*

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **EUGEINITZIA** gen. nov.

Eugeinitzia proxima sp. nov.

Plate 10, fig. 10; Pl. 25, figs. 1–3

Remains consisting of peltate, usually six-sided cone scales, with a median depression occupied by a process similar to that found in the peltate end of cone scales of *Sequoia;* pelt attached to the axis of the cone by a relatively slender stalk; center of the stalk occupied by a fibrovascular cylinder surrounding a medullary core; resin passages abundant in the cortical tissues, but wanting in the pith and in the wood of the central cylinder; a layer of periderm occupying, apparently, the lower side of the stalk.

These cone scales, of which we have found a considerable number of specimens, most of them in a fair condition of preservation, bear a superficial resemblance to those of *Sequoia* and are hardly distinguishable from many similar scales referred to that genus and to the fossil genus *Geinitzia* by various authors in their descriptions of Cretaceous plants, although we have not been able to definitely correlate our specimens with any particular species.

Figure 10, Pl. 10, shows the external appearance and characters of one of these scales, × 5. The resemblance to *Sequoia* may be seen in the well-defined process which occupies the median depression, while the six-sided outline of its peltate end is a feature strongly suggestive of *Geinitzia.* The stalk, by which the pelt is attached to the axis of the cone is, however, much slenderer than in *Sequoia* and more nearly like that of *Geinitzia.* There were no indications of the attachment of seeds, either to the stalk or to the peltate portion of the scale.

Figure 1, Pl. 25, is a transverse section, × 40, through the stalk of the cone scale shown in fig. 10, Pl. 10. The center of the figure is occupied by a fibrovascular cylinder surrounding a medullary core, just as is found to be the case in the cone scales of *Sequoia.* There are no resin canals in the pith or in the wood of the central cylinder. Resin passages are, however, abundant in the cortical tissues. On what appears to be the lower side of the stalk of the cone scale is a layer of periderm. Figure 2, Pl. 25, shows a transverse section, × 40, of the same cone scale at a slightly higher level. The woody

cylinder has grown larger and shows a concave depression on its upper surface. The bundles at this stage begin to separate from each other and, contrary to the conditions found in *Sequoia,* diverge widely into the very much flattened peltate portion of the cone scale. So quickly does the expansion of the narrow stalk into the flattened terminal shield-portion take place, that it is almost impossible to secure a section showing the transition from the one to the other. The small bundles arrange themselves around the margins of the disk and *become completely surrounded with transfusion tissue,* a feature of marked contrast to the scale bundles in *Sequoia* and at the same time one which indicates a strong affinity with the Araucarineae. In *Sequoia,* as has been pointed out by the junior author,[40] there are in the upper portion of the bundles of the cone scales lateral wings of transfusion tissue connecting the bundles with one another. In fact in the cone scales of the Sequoiineae and Cupressineae there is present the same type of transfusion tissue which is shown in the leaf-bundle of *Cunninghamia sinensis,* as figured by De Bary.[41] In this type of transfusion tissue the tracheidal cells originate from the flanks of the bundles and do not encircle the whole strand as in the vegetative leaves of the Abietineae or envelop the phloem part of the strand as is often the case in the bundles of the cone scales of living representatives of the Araucarineae. It has not been possible to trace any of the strands of the peltate portion of the cone scales under discussion into cicatrices of ovules, so that the attachment of the ovules in this case was probably on the stalk of the peltate scale near the axis of the cone. This view of the matter is strengthened by the discovery of one immature and carbonized cone composed of peltate scales, in which there are the remains of four ovules on the peduncular portion of each scale. Unfortunately the specimen is completely carbonized and cannot be sectioned to discover its possible affinities with the isolated mature scales described above. Figure 3, Pl. 25, shows a transverse section, × 100, of one of the numerous small bundles found about the margin of the disk in the mature scales under discussion. It may be clearly made out that there is a radial disposition of the transfusion tissue around the bundle, which appears as a cluster of smaller cells in the center of the larger transfusion elements.

[40] Mem. Boston Soc. Nat. Hist. 5: 449. *pl. 70. f. 23.* 1903.

[41] Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns, *fig. 183,* p. 380.

It seems highly probable that the cone scales of this type are of araucarineous affinities, especially as they are associated with numerous leafy branches of so-called *Sequoias,* which we have shown to be in reality twigs of araucarineous conifers, and this view of the matter is rendered the more probable by Endlicher's reference of *Sequoia Reichenbachi,* undoubtedly an araucarineous conifer, to the genus *Geinitzia* (*l. c.*), to which the isolated cone scales described above may well belong, since they show all the external characters of the scales found attached to complete cones in this genus. It appears then not unlikely that the cone scales just described may belong to the above or to an allied species, and if such should be determined to be the case, the original specific name would have to be substituted for the one here proposed.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **PSEUDOGEINITZIA** gen. nov.

Pseudogeinitzia sequoiiformis sp. nov.

Plate 10, fig. 11; Pl. 25, fig. 4

Remains consisting of peltate, four-sided scales; outer end of the fibrovascular cylinder of the stalk somewhat more gradually expanded than in *Eugeinitzia,* thus more nearly resembling *Sequoia.*

Only a single specimen of this type was found. It is shown, × 5, in fig. 11, Pl. 10. The condition of preservation was such that it was only possible to secure fairly good sections through the stalk. Part of one of these, in transverse section, × 100, is shown in fig. 4, Pl. 25. There is the same tubular fibrovascular cylinder as in the scales previously described, but in this type the expansion of the outer end is somewhat more gradual and resembles more or less the conditions found in *Sequoia* itself. It has not been possible to secure satisfactory sections of the peltate portion, but enough was made out to make it certain that the bundles surrounding the margin of the peltate disc in this case have the same encircling zone of transfusion tissue as in the scales described above. There seems in fact good reason to consider this scale, as well as the other, as araucarineous and as possibly belonging to the one genus, since the outline of the cone scale may not, perhaps, be regarded as a sufficiently important feature to bring about a generic separation, where the internal struc-

ture so closely agrees. It seems probable that where the cone axis of *Geinitzia* was much elongated the peltate expansions of the cone scales are hexagonal by contact with numerous other scales and that on the other hand, where the cone axis was short, in analogy with the living *Sequoia,* that the scales may have been generally four-sided. Among American figures which indicate elongated cones with six-sided scales may be cited the following,[42] referred to *Sequoia gracillima* (Lesq.) Newb., while the shorter type, with four-sided scales, may be clearly seen in the cone attached to a leafy branch, figured by Fontaine[43] and referred to *Sequoia ambigua* Heer.

We have thought it advisable to distinguish between those *Geinitzias* which have the long cone and hexagonal scales and those which have the short cone with tetragonal scales, by making the two new genera, *Eugeinitzia* and *Pseudogeinitzia.* In that case our first described scale would come under *Eugeinitzia* and the second under *Pseudogeinitzia.* It may, of course, turn out that the length of the cone is not a determining factor in the number of angles of the cone scale, in which case the shape of the scales may alone be taken into consideration in bestowing the names suggested.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimen in Jeffrey collection, Cambridge, Mass.

Genus PROTODAMMARA Hollick and Jeffrey

PROTODAMMARA SPECIOSA Hollick and Jeffrey

Plate 4, figs. 1–11; Pl. 10, figs. 1–3; Pl. 14, figs. 1, 4, 5; Pl. 15, figs. 1–6; Pl. 16, fig. 1

Protodammara speciosa Hollick and Jeffrey, Amer. Nat. 40: 199. *pl. 1. f. 5–13; pl. 2, f. 1–5.* Mch., 1906.

Dammara minor Hollick, Monog. U. S. Geol. Surv. 50 (Cret. Fl. S. N. Y. and N. Eng.): 40. *pl. 2. f. 35–37.* 1906.

"*Dammara microlepis* Heer (?)." Hollick, Ann. N. Y. Acad. Sci. 11: 57. *pl. 3. f. 9a, 9b.* 1898.

These little cone scales, which we have thus far only found detached, are very abundant in the lignitic debris of the Androvette pit. Their araucarineous affinities have been determined beyond

[42] Berry. Bull. N. Y. Bot. Gard. 3: *pl. 48. f. 21, 22.* 1903.
Newberry. Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): *pl. 9. f. 1.*

[43] Monog. U. S. Geol. Surv. 15 (Potomac or Younger Mesoz. Fl.): *pl. 120. f. 6, 6a.*

question (*l. c.,* Amer. Nat., pp. 199, 200, *pl. 2, f. 1–5*) and their relationship to *Brachyphyllum* is not improbable (*l. c.,* p. 204).

In figs. 1–9, Pl. 4, are shown a number of the scales, natural size, which indicate the variation in size and shape that may be found among them. Figures 10, 11, Pl. 4, represent respectively a narrow and a broad form, × 10, in which the acuminate apical process may be seen, as well as the three seed scars and the numerous longitudinal resin canals on the lower surface. Figures 1–3, Pl. 10, show other typical specimens, similarly enlarged.

Figure 5, Pl. 14, shows a transverse section, × 40, through the base of one of the cone scales. In the lower part of the figure may be seen indications of the seven resin canals, which are ordinarily found on the inferior surface. The upper part of the scale is largely sclerified and the superficial tissues are covered by a layer of periderm. The magnification is not sufficient to show the very small fibrovascular bundles, which are present in the base of the scale.

Figure 3, Pl. 15, shows the center of the upper portion of the last mentioned figure, × 100. Four minute fibrovascular bundles may be made out, three of which have their wood orientated upwards and a single one above has its xylem directed downwards. At a lower level than is represented in this figure there is a single bundle present in the scale, in which the wood is uppermost. At a slightly higher level a single bundle of opposite orientation is derived from the upper surface of this bundle, after which the original bundle divides into three, as may be seen in the figure. After the separation of the upper bundle the scale broadens considerably, as is shown in transverse section, × 30, in fig. 1, Pl. 15, being characterized at this stage by two thin lateral wings. Figure 2, Pl. 15, shows another transverse section of the cone scale, × 30, at about its thickest and broadest part, where it gives attachment to the three ovules. The bundles of the upper and lower series lie nearly in a line about the transverse middle of the scale. It is not easy to distinguish the upper and the lower series from one another, nor has it been possible to make out just when the upper, originally single, bundle divides into three for the supply of the three ovules. Figure 5, Pl. 15, shows a transverse section, × 40, through the median part of the scale at about the same level as that shown in fig. 2. Below may be seen the central of the seven resin canals, which characteristically occupy the lower portion of the scale. Above the resin canals

may be seen a lighter stripe, mainly composed of the abundant transfusion tissue, which surrounds the bundles on all sides and at the same time connects them with one another. Figure 4, Pl. 15, shows the upper part of a transverse section, × 80, through nearly the same region as fig. 5. Above may be seen the central ovular bundle which passes into the median ovule. This and its two lateral companions appear to bend very sharply upwards from the complex of bundles occupying the horizontal middle of the ovuliferous scale below the attachment of the ovules. Below may be made out one of the lower series of bundles which lies immediately above a resin canal. Figure 6, Pl. 15, is a transverse section, × 180, through one of the inferior bundles of the cone scale, showing it surrounded by a thick cordon of transfusion tissue on all sides. The tracheids of the bundle may be distinguished by their small size, their central position and the dark hue of their walls. The lighter colored cells which surround the bundle are transfusion elements with small bordered pits, very similar to those which surround the fibrovascular bundles of the needles in living pines. Similar cordons of transfusion tissue have been described by Seward and Ford in the case of the bundles of the cone scales of species of *Araucaria*,[44] and have been likewise observed by one of us in species of *Agathis*. It is of interest to note in this connection that this probably ancestral type of relation of the transfusion tissues to the foliar trace is best marked in the vegetative leaves of the Abietineae and in the cone scales of the Araucarineae. It may be stated in general that the cone scales of the Araucarineae, living and extinct, can often be distinguished in an isolated condition from those of the Cupressineae and Sequoiineae by the cordon of transfusion tissue which surrounds the fibrovascular bundles on all sides, since in the last two mentioned tribes the transfusion tissue had characteristically the same disposition as is found in their foliage leaves, viz., on the flanks of the bundles only.

Figure 1, Pl. 14, represents a longitudinal section, × 30, of a cone scale of *Protodammara*, a little to one side of the median longitudinal line. To the left is the spinous process, which is a usual feature of the cone scales of this genus, and which represents the end of the sterile bract, on the hypothesis that the araucarian ovuliferous scale is made up of the fusion of a pair of superposed scales equivalent to those found in the female cone of the Abietineae. The bulg-

[44] Philos. Trans. Roy. Soc. London B 198: 363. *f. 27.* 1906.

ing upper part of the cone scale ends to the right in a minute pit, which marks the point of attachment of the median ovule. Passing downwardly to the right of this pit may be seen a dark stripe, the fibrovascular supply of the ovule. Below the projecting convexity of the upper surface of the scales are to be seen stone cells in the substance of the scale. Lower down still is a dark somewhat upwardly concave stripe, which is one of the fibrovascular bundles of the lower series. It is jacketed above and below with transfusion tissue. Below the transfusion tissue is the large central resin canal of the cone scale. The lower surface of the scale ends in a free surface or apophysis, the inferior limit of which is indicated by a marked depression. Figure 4, Pl. 14, shows another longitudinal section of the same scale, $\times$ 40, in a somewhat different plane. In this case the ovular depression can still be seen on the upper surface. The central resin canal of the scale is to be seen passing out into the base of the terminal spine.

Figure 1, Pl. 16, shows another approximately median plane of longitudinal section, $\times$ 30, in which the median resin canal is seen to have passed out into the terminal spine. The figure in this case is inverted to save space.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **ANOMASPIS** gen. nov.

Anomaspis tuberculata sp. nov.

Plate 10, figs. 5, 6; Pl. 25, fig. 5; Pl. 26, fig. 1

Remains consisting of peltate cone scales, irregularly pentagonal (?) in outline; pelt without any median depression, surface flat or somewhat rounded, covered with polygonal tubercles; stalk slender below, rapidly expanding into the pelt above; substance of the scale occupied by numerous irregularly disposed strands of sclerenchyma, in the meshwork of which are the fibrovascular bundles; bundles irregularly disposed, ending in a cordon of transfusion tissue in the tubercles.

In addition to the cone scales previously described, several other types were found in the material from the Androvette pit. Superficial views, $\times$ 10, of the one now under discussion, are shown in figs. 5, 6, Pl. 10, together with a similarly magnified figure of a small

cone scale of *Sequoia gigantea* Torr., in fig. 7, Pl. 10, for comparison, in order to illustrate their striking external contrast. Figure 5 shows a somewhat lateral view so as to bring out the character of the slender stalk or peduncle rapidly expanding into the peltate disc. Figure 6 shows the characteristic tuberculate, rounded surface, without any median depression.

Figure 5, Pl. 25, shows the internal structure of the species as seen in transverse section, × 12. Figure 1, Pl. 26, shows a view of a portion of the same section, × 40. The substance of the scale may be seen to be occupied by numerous irregularly disposed strands of sclerenchyma, interspersed in the meshwork of which are the fibrovascular bundles. The intensely black cells which make up a large portion of the rest of the scale are for the most part cells surrounding resin canals. In the living *Sequoia,* a transverse section of the cone scale of which, × 8, is represented in fig. 6, Pl. 25, the bundles are arranged in a lower and an upper series and have not the scattered disposition shown in our fossil. The numerous irregularly disposed bundles in the cone scales under discussion end in a cordon of transfusion tissue in the tubercles described above as ornamenting the flattened surface of the peltate expansions. The structure of these terminations of the fibrovascular strands of the cone scales suggests araucarineous affinities.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Anomaspis hispida sp. nov.

Plate 10, figs. 4, 8, 9

Remains consisting of peltate cone scales, similar in external appearance to those of *A. tuberculata,* except that the surface of the pelt is not tuberculate but is covered with rather minute hispid projections.

The exterior of one of these scales, × 10, is shown in fig. 4, Pl. 10. The internal structure does not differ materially from the species last described, but unfortunately in neither species are the tissues well preserved, so that it has not been possible to diagnose their structure very satisfactorily; but, so far as can be judged, their relationship with the Araucarineae may be assumed, at least provisionally. Cone axes of this species, × 10, are shown in figs. 8, 9, Pl. 10.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **SPHENASPIS** gen. nov.

Sphenaspis statenensis sp. nov.

Plate 10, figs. 22, 23; Pl. 26, figs. 2–4

Remains consisting of cone scales, wedge-shaped below, somewhat peltate above; surface of the pelt hollowed in its upper part, the lower lip of the excavation conspicuously projecting as an obtuse cuspidate process; internal structure showing an upper and a lower series of fibrovascular bundles, the latter accompanied by resin canals, the phloem sides of both series surrounded by a thick zone of transfusion tissue.

This type of cone scale was found somewhat sparingly in the lignitic debris of the Androvette pit. The characteristic wedge-shaped base and projecting cuspidate process on the lower surface are well shown, × 10, in the side view represented by fig. 23, Pl. 10, which resembles the dental alveolus of a sea urchin. The hollowed outer surface is somewhat comparable to that of *Sequoia* and *Geinitzia,* but it lacks the process at the bottom of the depression and is clearly differentiated by the projecting cuspidate rim of the lower lip of the depression. Figure 22, Pl. 10, shows the appearance, × 10, of the inner basal portion and part of the upper surface of the scales, viewed from in front and slightly from above.

A transverse section of the scale, × 15, is shown in fig. 2, Pl. 26. A series of numerous bundles stretches across what appears to be the upper side. On the lower there are fewer bundles and a number of large cavities which represent more or less disorganized resin canals. Figure 3, Pl. 26, represents a transverse section, × 15, at a higher level, in an inverted position to that shown in the previous figure. There is now a space in the center which represents a transverse section of the terminal depression. Figure 4, Pl. 26, is a portion of the latter section, × 100, showing one of the upper series of bundles, in which the phloem side is surrounded by a thick zone of transfusion tissue. This condition, which is found in both series of bundles, is a clear indication of araucarineous affinities. On account of their characteristic wedge-like shape and somewhat peltate ends we have adopted for these scales the generic name *Sphenaspis,* and a specific name which indicates the place where they were discovered.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **DACTYOLEPIS** gen. nov.

Dactyolepis cryptomerioides sp. nov.

Plate 10, figs. 12, 13

Remains consisting of cone scales composed of an upper and a lower segment, the upper one divided into as many as seven subdivisions or finger-like processes, the lower one undivided; each of the upper subdivisions containing a fibrovascular bundle which is completely surrounded by a cordon of transfusion tissue; lower segment also containing fibrovascular strands.

This type of cone scale is of somewhat rare occurrence in the macerated debris from the Androvette pit. Specimens, × 10, are shown in figs. 12, 13, Pl. 10. It is of particular interest because its general appearance suggests at once the living genus *Cryptomeria* and also certain species of the extinct genus *Voltzia*. We have not been able to make out any indication of the number or mode of attachment of the seeds. Most of the specimens are poorly preserved; but in one instance we were able to obtain a section which afforded sufficient data to clearly indicate its affinities. Each of the finger-like processes of the upper segment in this specimen was found to contain a fibrovascular bundle completely surrounded by a cordon of transfusion tissue, thus betraying its araucarineous relationship. In the lower segment the fibrovascular supply was too much carbonized to decipher, although its presence was quite apparent.

It is evident, in spite of the external appearance, that these scales cannot be related to *Cryptomeria;* but their resemblance to certain species of *Voltzia* may have considerable significance, and if there should be any close affinity between our specimens and the latter genus, this will have to be removed from the Sequoiineae, where it is generally supposed to belong, and placed in the Araucarineae, and such an eventuality would only be in accord with the general results which we have obtained in our study of the coniferous flora of the Kreischerville deposits. The conspicuous finger-like processes naturally suggested for these scales the generic name *Dactyolepis,* and the resemblance to *Cryptomeria* suggested an appropriate specific name.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus **PITYOIDOLEPIS** gen. nov.

Pityoidolepis statenensis sp. nov.

Plate 9, figs. 13, 14; Pl. 27, figs. 1–3

Remains consisting of cone scales having a superficial resemblance to those of the female cones of the American and Mexican nut pines, but lacking the depressions on the inner surface corresponding to the large seeds of these species. On the opposite surface is a well-marked apophysis, distinguished by a distinct transverse ridge, which appears to resemble the umbo of a nut pine, but without any evidence of annual growth as in the umbo of *Pinus*.

A somewhat commoner type of cone scale from the Androvette deposit is one which had the general appearance of the scales of the female cone of one of the American or Mexican nut pines. The scales in question have the slender base which is found in certain nut pines, but are without the depressions corresponding to the large seeds of this section of *Pinus*. They have on the opposite surface a well-marked apophysis, distinguished by a distinct transverse ridge, which on superficial examination in badly preserved material appears to resemble the umbo of a nut pine. It is really not comparable to an umbo, however, as it does not exhibit in the mature scale the evidence of annual growth, which is inseparable from the idea of an umbo as it occurs in *Pinus*. Figures 13, 14, Pl. 9, representing two of these scales, × 10, sufficiently establish the truth of the above statements.

Figure 1, Pl. 27, shows the structure of the lower part of such a scale, in transverse section, × 25. The lower side of the scale is occupied by a series of resin canals, above which lie a series of small fibrovascular bundles. Above these again is a second series of bundles of inverted orientation. The lower bundles are distinguished particularly by the cordon of transfusion tissue, which surrounds them. In the upper series there is a median bundle much stronger than the others, which probably represents the vascular supply of a single median seed. Figure 2, Pl. 27, represents a similar section, × 100, showing on the lower side one of the inferior bundles with its jacket of transfusion tissue, and above the large median bundle

of the superior series, which probably represents the ovular supply. Figure 3, Pl. 27, illustrates, in similar section and magnification, the structure of one of the bundles of the lower series which is almost surrounded by a transfusion tissue, the tracheary cells appearing as small elements in the center of the larger transfusion cells. In the case of this species of scale again we have in all probability to do with part of an araucarineous female cone. On account of its superficial resemblance to the cone scales of *Pinus* we have given it the generic name *Pityoidolepis* and have indicated its place of discovery in the specific name. We have found not a few fragments of flattened cones made up of scales of this species, which would in all probability, in impressions, be taken for cones of *Pinus*.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus ARAUCARIOPITYS Jeffrey

ARAUCARIOPITYS AMERICANA Jeffrey

Araucariopitys americana Jeffrey, Bot. Gaz. 44: 435. *pls. 28–30.* 1907.

This type of wood, found in the Androvette pit, we have not yet been able to definitely connect with any of the associated leafy twigs; but we have reasons for suspecting that it may represent the wood of *Czekanowskia*. It is clearly, however, an araucarineous conifer, as demonstrated by its internal structure and hence if the reference to *Czekanowskia* should turn out to be correct, this latter genus would have to be placed in the Araucarineae instead of in the Gingkoales, where it is generally considered to belong. The species is fully described and illustrated in the paper above cited, and any further discussion of its characters does not seem necessary.

Genus **BRACHYOXYLON** gen. nov.

Brachyoxylon notabile sp. nov.

Plate 13, figs. 2–6; Pl. 14, fig. 2

"*Brachyphyllum macrocarpum* Newb." Hollick and Jeffrey, Amer. Nat. 40: 203 [desc.], 214 [name]. *pl. 5. f. 1–4.* Mch., 1906.
"*Araucarioxylon* sp." Ibid. *f. 5, 6.*

"Wood of *Brachyphyllum*." Jeffrey, Annals Bot. 20: 384–386. *pl. 27. f. 1–12.* Oct., 1906.

Radial pits not all alternating or mutually flattened as in *Araucarioxylon* Kraus, but as often or more frequently of rounded configuration and not contiguous. The alternating or flattened condition of the radial pits generally confined to the terminal walls of the tracheids. Resiniferous elements characteristically absent. Wounds leading to the formation of traumatic resin canals, which are not present under any conditions in *Araucarioxylon* Kraus (*Emend.* Hollick and Jeffrey).

In our preliminary paper in the American Naturalist (*l. c.*) we identified certain araucarineous lignites present in the Androvette pit as probably the wood of *Brachyphyllum*. As a result of our fuller knowledge, derived from a continued study of the Staten Island lignites, we are no longer in the position to affirm that these fragments of fossil wood actually represent the wood of the genus *Brachyphyllum*, for, as we have determined, a number of other araucarineous conifers, which have in general been erroneously referred to other tribes of the Coniferales, possess the same general type of wood structure. The correct statement of facts appears to be that during the Cretaceous and earlier Mesozoic times there were present numerous representatives of a peculiar araucarineous tribe or sub-tribe, essentially different in anatomical structure from the genera of the Araucarineae still living. *Brachyphyllum* was only one of the numerous genera of this important group, which in all probability ceased to exist in the changes which ushered in the Tertiary period. The fact that on account of the richness of the display of this type of araucarian and the uniformity of ligneous structure presented by it, it is no longer possible to relate the lignitic fragments of wood to any one genus, makes the fuller knowledge of this type of wood not less but rather more important than at first appeared to be the case.

Figure 2, Pl. 13, shows a transverse section of this wood, × 40. Three annual rings are included in the field of view. The wood is conspicuously without resiniferous elements, so far as can be judged from this section. Figure 4, Pl. 13, shows a longitudinal section of the same specimen, × 180. The pits occur in a single row as in the case in the small-leaved species of the living *Araucaria*. They have the araucarian peculiarity of being flattened by mutual contact. In fig. 5, Pl.

13, is shown another similar section of the same specimen under the same magnification. Here occur in a single tracheid the alternating pits, which are generally present in the living araucarian genus *Agathis* and in the section *Colymbea* of *Araucaria*. This condition of affairs is comparatively rare in our fossils. In fig. 3, Pl. 13, is another longitudinal section of the same specimen similarly magnified. This section represents, on the whole, the commonest condition of the pitting. It may be observed in this case that the pits, which are present in a single row are *not* flattened by mutual contact, and thus present an agreement with the pitting found in the remaining tribes of the Conferales. This feature appears to be of great importance, since the strictly flattened or alternate pitting of the living *Agathis* and *Araucaria* has suggested a relationship between them and the Cordaitales, in which the pits entirely cover the walls of the tracheids and are of the alternating type. The general trend of opinion of those who have in recent years investigated the Coniferales is that the araucarian group is the oldest and that it bears a more or less close degree of relationship to the Cordaitales. *Brachyphyllum* and allied genera afford reasons for strongly doubting the correctness of this view, for representing as they do an older and now quite extinct branch of the Araucarineae, they nevertheless show in their pitting, and in other features, characters which are less araucarian than those found in the living genera *Agathis* and *Araucaria*—features, moreover, which approximate the araucarian stock to the Abietineae rather than to the Cordaitales. Figure 6, Pl. 13, shows a tangential view of the summer wood of the lignite under discussion, $\times$ 180. The tangential pitting of the tracheids and the generally shallow character of the medullary rays can be made out.

Figure 2, Pl. 14, representing a transverse section of the wood, $\times$ 40, shows the nature of the wound reaction in this lignite. This phenomenon has been described by the junior author for this and similar lignites in an earlier article;[45] but it is advisable for completeness to refer to the matter again here. Contrary to the condition of affairs found in the living genera of the Araucarineae, a wound in the case of the clearly marked group of conifers for which *Brachyphyllum* in the present instance may stand as an example, results in the formation of traumatic resin canals such as occur under similar conditions in the Abietineae. In the figure last cited a row of somewhat

[45] Annals Bot. 20: 383–394. *pls. 27, 28.* 1906.

compressed vertical resin canals may be seen to stretch away from the right-hand side of the mass of wound callus, which marks the site of a healed wound. It may be seen from the above data that the type of wood found in the well-marked extinct group of araucarineous conifers represented by *Brachyphyllum* and by the lignitic fragments just described, differs from that present in the living *Agathis* and *Araucaria* in several important particulars, which serve to relate the group in question to the Abietineae. Since this type of wood is quite distinct and easily recognizable, it seems very desirable that it should bear a special and distinctive name, which will clearly separate it from *Araucarioxylon* Kraus. In the latter genus the pits are always alternating or at least flattened by mutual contact, while in the type under discussion they are quite as often remote and round in configuration as they are flattened by mutual propinquity, and seldom or never alternate. The resiniferous elements which are commonly, although not universally, present in the wood of *Araucaria* and its immediate allies are absent, so far as we have been able to distinguish, in rather abundant material of *Brachyphyllum* and related genera. Further, wound reactions, which, contrary to what might be supposed, are frequently represented in fossil woods, supply a clear distinction between *Araucaryoxylon* and the type under discussion; for in the latter wounds lead to the formation of traumatic resin canals, such as have not been found to occur in *Araucarioxylon* or in the wood of *Agathis* and *Araucaria*.

We have considered it advisable to discuss at length this new type of araucarineous wood and to designate it by the generic name *Brachyoxylon* in order to define its affinities, since it is very abundant in the Kreischerville deposits and is found to characterize leafy twigs which on the basis of the vegetative habit alone, have been referred to almost all tribes of the Coniferales, other than the Abietineae and Araucarineae.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus ARAUCARIOXYLON Kraus

Araucarioxylon noveboracense sp. nov.

Plate 21, figs. 1–3, 5, 6

"Wood of *Araucaria* or an allied genus." Jeffrey, Annals Bot. 20: 388. *pl. 28. f. 14, 15.* 1906.

In fig. 1, Pl. 21, is shown a transverse section, × 40, of an *Araucarioxylon* which is very common in the lignitic remains found in the Drummond pit. We have not found a single fragment of any similar remains in the Androvette pit, which supplied practically all the leafy twigs with structure sufficiently well preserved for more or less accurate diagnosis. This *Araucarioxylon* was previously figured and described as the wood of *Araucaria* or an allied genus, in a paper on "The Wound Reactions of the Genus *Brachyphyllum*" in the Annals of Botany, above cited, but a fuller description is here supplied. Figure 1 may be compared with the similar section of *Brachyoxylon* shown in fig. 2, Pl. 13, having the same degree of magnification. It may be seen that in our specimen of *Araucarioxylon* the tracheids are considerably larger than they are in the lignites presenting the structural peculiarities of the genus *Brachyphyllum*, and that, further, there are somewhat numerous cells present with dark contents, comparable to similar cells occurring in the wood of certain species of the living *Agathis* and *Araucaria*. Such cells appear to be absent in the lignites of the *Brachyphyllum* type. Figure 2, Pl. 21, is part of the section shown in fig. 1, × 180. The resiniferous cells interspersed among the tracheids may be still more clearly made out in this figure and the additional fact may be discerned that the tracheids are filled with a matrix similar to the mucilaginous contents found in the tracheids in wounded roots of living species of *Agathis* and *Araucaria*, as one of us has observed. This matrix is in all probability of the nature of a fossilized gummy secretion, formed as a result of wounding. This conclusion gains strong probability from the fact that in the actual trunk from which this section was made, which still retained its bark, numerous citatrices were present on the outside of the stem as well as evidences of healed wounds in the deeper layers. In the article on the wound-reactions of *Brachyphyllum*, above cited, mention has been made of the nature of the wound-reactions in living araucarians. Figure 4, Pl. 21,

shows the margin of a healed wound in *Agathis alba* (Rumph.) Salisb., from material derived from the Botanical Garden at Buitenzorg, Java. There is a considerable amount of callus parenchyma on the right of the figure and some of the tracheids adjacent to this are blocked with mucilage. To the left of the wound-callus the tracheary tissue presents a normal appearance. This condition is to be contrasted with the state of affairs found in the *Brachyoxylon* type of wood, as represented in our fig. 2, Pl. 14, which shows a row of traumatic resin canals running from the callused margin of a healing wound. We have found that *Brachyoxylon* presents this marked contrast to *Araucarioxylon,* viz., that whereas traumatic resin canals are characteristically formed as the result of wounding in the former, they are invariably absent in the latter. That a similar contrast occurs in our *Araucarioxylon* is clearly shown in our fig. 3, Pl. 21, which represents a transverse section of the wood, $\times$ 40, and shows the margin of a healed wound in this species, for there is the same absence of traumatic resin canals which is found to be characteristic of the living genera *Agathis* and *Araucaria.* We have made a large number of observations on this point and feel that the above general statement as to the absence of traumatic resin canals holds as strictly in the case of our fossil as it does in the case of the genera last mentioned. Figure 5, Pl. 21, shows a longitudinal radial section of the wood of our *Araucarioxylon,* $\times$ 180. The preservation is not good and this, together with the presence of mucilage on the tracheids, somewhat obscures the structural features. It may be noticed that the pitting is strictly of the type found in *Agathis* and the large-leaved *Araucarias* of the section Colymbea, for the bordered areas are for the most part in several rows per tracheid and are uniformly alternate. We have found the condition of alternation or mutual flattening to be universal in this wood, just as it is in *Araucaria* and *Agathis.* Figure 6, Pl. 21, shows another radial section under the same magnification, which elucidates the structure of the resiniferous elements. One of these is shown in the middle of the field, which is crossed by a transverse septum. The resin cells in our species are of the nature of resiniferous parenchyma similar to that found in *Cupressinoxylon* Goepp. and present a contrast to the resiniferous tracheids which are found in *Agathis australis* (Lamb) Salisb. They resemble, however, similar parenchymatous resinif-

erous elements which occur in the wood of *A. alba* and other species of the living Araucarineae.

It may be seen from the above description that our *Araucarioxylon* presents a close resemblance to the structure of wood found in the modern genera of the Araucarineae, but differs from the extinct type of araucarineous wood which we have described under the name *Brachyoxylon,* in the invariable flattening or alternation of the radial pits; in the presence of resiniferous xylem parenchyma, and in the absence of traumatic resin canals. In *Brachyoxylon* the pits are frequently not marked by flattening due to mutual contact but are often round as in the Abietineae. Alternation of the pits is generally absent on account of the small size of the tracheids. Resiniferous parenchyma does not occur. Traumatic resin canals in the latter genus, in contrast to *Araucarioxylon,* are present. It is obvious that we have in *Brachyoxylon* a clearly defined type of araucarineous wood, which is strikingly different from the ordinary *Araucarioxylon* type. Wood of this type have apparently not escaped the attention of other observers, although their points of difference from the ordinary *Araucarioxylon* type have not been recognized. Seward, for example, has figured an araucarineous wood, which he calls *Araucarioxylon Lindleii,*[46] which is characterized by rows of intercellular spaces, similar to those seen in our fig. 2, Pl. 14, which he compares with the resin canals of the Abietineae, but considers them not to be regular enough to merit the name of resin canals. In his *fig. 3, pl. 7* (*l. c.*), their appearance is quite as regular as the traumatic resin canals found in the abietineous genus *Tsuga;* while Goeppert has figured the pits of the wood as seen *in actual leafy branches* of the ancient araucarineous genus *Ullmannia* as occuring in a *single row and not flattened by mutual contact.*[47] This is a much more likely description of the wood of this ancient Mesozoic conifer than that figured by Zittel[48] from associated fossil woods, which were not certainly the remains of *Ullmannia,* and may well from the nature of their pitting have belonged to *Cordaites.* The question as to the relative antiquity of the *Araucarioxylon* and *Brachyoxylon* types of araucarineous woods has an important bearing on the subject of the phylogeny of the Coniferales, as already discussed in connection with certain other

[46] Cat. Mesoz. Plants, Dept. Geol., Brit. Mus. (Jurassic Flora, Pt. II, Liassic and Oölitic Flora), 56. *pl. 6. f. 1–4; pl. 7. f. 2–5.*

[47] Monog. Foss. Conif. *pl. 20. f. 3.*

[48] Handb. Palaeont., Abth. II, 275. *f. 190.*

facts derived from the study of the internal structure of Cretaceous araucarineous cone scales.

Locality: Drummond pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

CONIFEROUS REMAINS OF UNDETERMINED RELATIONSHIP

Sequoia heterophylla Velenovský

Plate 3, figs. 11–13

Sequoia heterophylla Vel. Gymnosp. Böhm. Kreideform. 22. *pl. 12. f. 12; pl. 13. f. 2–4, 6–9.* 1885.—Hollick, Trans. N. Y. Acad. Sci. 12: 30. *pl. 1. f. 21.* 1892; Monog. U. S. Geol. Surv. 50 (Cret. Fl. S. N. Y. and N. Eng.): 41. *pl. 3. f. 2, 3.* 1906.

Only a few fragmentary specimens of this species were found, consisting of impressions of leafy twigs in the clay layers. Three of the best of these are represented, natural size, in figs. 11–13, Pl. 3. No remains which could be definitely identified as belonging to the species were found in the lignitic debris, hence we have been unable to determine what its true botanical affinities may be, as in no instance was any specimen sufficiently well preserved for sectioning and microscopical examination.

The identity of our specimens with those which have been recognized under the above name cannot, however, be questioned; although, from what we have learned in regard to other fossil species commonly referred to the genus, such reference must be regarded as wholly tentative.

Locality: Androvette pit, Pl. 3, figs. 11, 13. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Mus. Staten Island Assoc. Arts and Sci.

Old excavation, southwest of Killmeyer's hotel, Pl. 3, fig. 12. Collected by Arthur Hollick. Specimen in Mus. Staten Island Assoc. Arts and Sci.

Juniperus hypnoides Heer

Plate 5, figs. 5, 6

Juniperus hypnoides Heer, Fl. Foss. Arct. 6[2]: 47. *pl. 44. f. 3, 4; pl. 46. f. 18.* 1882.—Hollick, Trans. N. Y. Acad. Sci. 12: 29. *pl. 1.*

f. 1. 1892; Monog. U. S. Geol. Surv. 50 (Cret. Fl. S. N. Y. and N. Eng.): 46. *pl. 3. f. 12.* 1906.

Juniperus macilenta Heer [?], Fl. Foss. Arct. 6²: 47. *pl. 35. f. 10, 10b, 11.*

The single specimen, represented natural size in fig. 5, Pl. 5, is the only one thus far brought to light in any of the Kreischerville material which could be definitely referred to this species; although isolated fragments, apparently belonging to it, are more or less abundantly represented in the lignitic debris. These latter, however, are difficult to distinguish superficially from other delicate coniferous twigs, unless the leaves are all preserved so that the phyllotaxy may be made out. Figure 6, Pl. 5, shows a terminal twig, with leaves attached, as it appears under an ordinary hand lens.

If the two species described by Heer are to be regarded as distinct, our specimen undoubtedly resembles *hypnoides* more nearly than it does *macilenta,* although specimens apparently identical with ours were described and figured by Newberry from the Cretaceous of New Jersey under the latter species.[49]

None of our specimens was found sufficiently well preserved for sectioning, so that we are unable to say whether the commonly accepted reference of this species to the genus *Juniperus* may or may not be justified. In this connection it is interesting to note that in the New Jersey clays the twigs of this tree are closely associated with cone scales of *Dammara borealis* Heer, which are undoubtedly closely related to our *Protodammara speciosa;* in fact, Newberry states that they are "sometimes apparently attached to the branchlets," and that "almost no other plant except this conifer is found with the cone scales, and it is difficult to avoid the conclusion that they belong together" (*l. c.,* p. 47). This association may possess some significance, inasmuch as we have found in similar association, in the Androvette pit, the twigs of *Juniperus* and the cone scales of *Protodammara,* which latter has been determined to be araucarineous in its affinities.

Locality: Androvette pit. Collected by William T. Davis. Specimen in Mus. Staten Island Assoc. Arts and Sci.

[49] Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 54. *pl. 10. f. 7.*

CZEKANOWSKIA CAPILLARIS Newberry

Plate 6, figs. 1–3

Czekanowskia capillaris Newb. Monog. U. S. Geol. Surv. 26 (Fl. Amboy Clays): 61. *pl. 9. f. 14–16.* 1895.

Closely packed masses, irregular shaped fascicles, and isolated fragments of linear, striated leaves, occasionally forked, occur abundantly in the clay layers of the Androvette pit. Two of these specimens, natural size, are shown in figs. 1, 2, Pl. 6. Many of the fragments in which the forking is not apparent have much the appearance of pine needles and may readily be mistaken for them; in fact, so far as the gross appearance of some of the masses of leaves is concerned, these could hardly be distinguished from similar remains of *Pinus Quenstedti* Heer.[50] They are evidently identical, however, with the remains described by Newberry under *Czekanowskia capillaris,* but referred by him with hesitation to this genus.

Some of our more robust specimens, however, such as the one represented by fig. 2, Pl. 6, may be satisfactorily compared with *C.* (*Sclerophyllina*) *dichotoma* Heer, from the Cretaceous of Greenland,[51] and with *C. nervosa* Heer, from the Cretaceous of Portugal,[52] which latter species has also been identified by Ward from the Cretaceous (Hay Creek series) of the Black Hills,[53] while the more delicate ones, such as are represented by fig. 1, Pl. 6, are more nearly like certain of the forms of *C. rigida* Heer, from the Jurassic of Siberia,[54] and as figured by Nathorst from the Triassic of Sweden.[55] Certain of these figures are in fact practically identical in general appearance with ours, and if the two series of figures are compared it is difficult to resist the impression of specific identity between them in several instances. It is also of interest to note, incidentally, that we find the same close association of these and certain other coniferous remains in the Androvette pit as is mentioned by Heer in his "Kreide-Flora" (*l. c.,* p. 60), where he says that the remains of *C. dichotoma* occur "*neben den Zweigen der Sequoia Reichenbachi.*"

[50] Kreidefl. Moletein, *pl. 3.*

[51] Fl. Foss. Arct. 3 (Kreide-Fl.): 59. *pl. 17. f. 10, 11, 11b; pl. 20. f. 6d.*

[52] Cont. Fl. Foss. Portugal: 17. *pl. 16. f. 5–7a, 8–11.*

[53] Nineteenth Ann. Rept. U. S. Geol. Surv. 1897–98, Pt. II: 685. *pl. 169. f. 1, 2.*

[54] Fl. Foss. Arct. 4 (Jura-Fl.): 70. *pl. 5. f. 8–11; pl. 6. f. 7; pl. 10. f. 2b;* ibid. 6 (Nachträge Jura-Fl.): 19. *pl. 6. f. 7–12.*

[55] Kgl. Fysiogr. Sälsk. Handl. 17[8] (Om Några Ginkgoväxter frän Kolgrufvorna vid Stabbarp i Skåne): 11. *pl. 1. f. 9; pl. 2. f. 2–15.* 1906.

The probable botanical relationship of the genus has never been satisfactorily determined, although the question has been discussed by nearly every author who has had occasion to study it. Heer says in his "Jura-Flora" (*l. c.*, p. 65), "*Die auf Taf. V. und Taf. VI. dargestellten Pflanzen stellen einen so eigenthümlichen Pflanzentypus dar, das es schwer hält, für denselben die richtige systematische Stellung auszumitteln*"; and he further remarks that the first impression is that the remains are bundles of pine needles, but that the forking of some of the leaves show that they cannot belong to this genus. Their resemblance to certain pteridophyta, especially to the genus *Isoëtes*, is then discussed, but is regarded as untenable, and the conclusion is finally reached that they probably belong in the Gingkoales. This conclusion seems to have been quite generally accepted by paleobotanists and the genus is now commonly regarded as closely related to *Trichopitys*, *Jeanpaulia* (*Baiera*), *Gingkophyllum*, etc.

It is unfortunate that in none of our specimens is the basal part preserved. It is probable, however, that fig. 1 represents an upper and fig. 2 a lower portion. Figure 3 represents an enlarged fragment of one of the forking branches as it appears under a hand lens.

In no instance have we been able to definitely identify any of the lignitic remains with the species under discussion, but it is possible that certain leafless twigs, showing well preserved internal structure, representing the genus *Araucariopitys* (see p. 54 of this Memoir), may belong to it, and if such should be the case, it would be another example of a conifer of araucarineous affinities from the Kreischerville deposits, in this instance simulating the Gingkoales in external appearance.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Mus. Staten Island Assoc. Arts and Sci.

Unidentified Twig

Plate 9, fig. 15; Pl. 20, fig. 6

Figure 15, Pl. 9, depicts a small coniferous twig, $\times$ 10, represented by a single specimen, which, however, sufficiently illustrates the external appearance of the species. It is strongly suggestive of certain twigs which have been described by Heer under the genus *Brachyphyllum*,[56] from the Jurassic and Cretaceous of Portugal

[56] *B. Delgadonum* Heer, Cont. Fl. Foss. Portugal: 10. *pl. 10. f. 4; B. corallinum* Heer, ibid.: 21. *pl. 12. f. 1–3.*

respectively, but our material is too scanty for any adequate comparison. Figure 6, Pl. 20, shows the twig in transverse section, × 60. The leaves are somewhat rhombic in transverse section and contain a single resin canal, as appears in the upper part of our figure. The specimen is too immature for identification, since the woody tissues are poorly developed and do not warrant the expectation that the pitting of the tracheids of the secondary wood will be made out in longitudinal sections, which have not been cut on account of the small amount of material.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Genus CUPRESSINOXYLON Goeppert

CUPRESSINOXYLON sp.

Plate 20, fig. 2

Although we have had occasion to frequently refer to the monotonously araucarineous structure of the leafy twigs and wood from the Kreischerville deposits, most of which present marked external resemblances to certain genera of the living Sequoiineae, Cupressineae and Podocarpineae, it should not be inferred that indications of the presence of plants with cupressinoid structure were entirely absent. We have found scanty remains of lignite referable to the genus *Cupressinoxylon,* but specific designation is withheld in the hope of being able, later on, to definitely identify them with certain of the leafy branches.

Figure 2, Pl. 20, shows the structure of this material in transverse section, × 40. Resin cells are very numerous, as in the *Cupressinoxylon* type of wood. Longitudinal sections of the wood serve to confirm the diagnosis, for there are numerous rows of resinous parenchyma present and the pitting of the tracheids presents no indications of araucarineous affinities. The lateral pits of the ray cells are few in number and large in size, which leads to the suspicion that we may have to do with a representative of the Podocarpineae. This conclusion is, however, to be accepted with some reserve, in spite of the attempt recently made by Gothan in his studies on the anatomy of living and fossil gymnosperm woods[57] to separate the wood of certain of the Podocarpineae from

[57] Abh. K. Preuss. Geol. Landesanst. II. 44: 47. 1905.

the general *Cupressinoxylon* type. This group of conifers needs a much more comprehensive study than it has received before it will be possible to distinguish clearly its characters, either ligneous or reproductive.

It is apparent from the data in regard to the *Cupressinoxylon* from Staten Island, above recorded, that the possibility of the existence of cupressineous conifers at so early a period is not excluded, although it is obvious that they could not have been very numerous. We hope to return to this phase of the subject on another occasion, when more abundant material may be at our disposal.

Locality: Drummond pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimen in Jeffrey collection, Cambridge, Mass.

Genus STROBILITES Lindley and Hutton

Strobilites microsporophorus sp. nov.

Plate 10, figs. 18–21; Pl. 24, figs. 2–6

Remains consisting of small, slender cones, much longer than broad; scales lanceolate-ovate, acute, closely imbricated, bearing on their edges numerous pollen grains or microspores, each of which is provided with two lateral wings or air sacs.

In the lignitic debris of the Androvette pit occur numerous minute, slender cone axes, almost never complete, covered with very small scales. The scales have often about their edges a yellowish brown substance, which on superficial examination appears to be of the nature of a resinous exudation. This substance, when viewed with the microscope in favorable cases, is seen to be made up of pollen grains or microspores, bearing two lateral wings, such as occur among living coniferous pollens in the Abietineae and Podocarpineae. The small cones which produce these microspores are obviously male aments of a conifer. It would be inferred from their pollen grains alone that they are either abietineous or podocarpineous in their nature.

Figures 18–21, Pl. 10, show the superficial characters of these male aments, $\times$ 10. Their length and slender proportions, when complete, make it difficult to regard them as belonging to the Abietineae, if such a reference were not negatived by their internal structure, as will be indicated at a later stage. The outward configuration of the scales is more in favor of their podocarpineous affinities, but

the anther sacs do not open by a stomium as is the case in *Podocarpus* and *Dacrydium* and, moreover, their microspores are not quite of the type found in the genera just mentioned.

Figure 3, Pl. 24, shows a view of a transverse section of one of these aments, × 30. In the center is the axis containing a number of small fibrovascular bundles, arranged in a circle. These bundles are of no diagnostic value, although well preserved, for they are entirely composed of spiral ringed and reticulate elements, as regards the xylem, and consequently do not show any pitted tracheids, which could be used to establish the systematic position of the remains. From the surface of the axis are derived a number of microsporophylls, each of which bears a pair of anther sacs. The pollen in the anther sacs, as has been pointed out, is winged, with two air chambers. Figure 2, Pl. 24, shows a longitudinal view of one of these small cones, × 30, as seen in tangential section. The fact that the anther sacs are in pairs may more readily be made out in this plane of section. In the right of the section may be distinguished the end of one of the microsporophylls. It is obviously tipped with a distinct process. Figure 4, Pl. 24, shows the process, × 100. It is largely occupied by a mass of transfusion tissue which forms a cordon about the bundle entering from the sporangiferous part of the lamina of the sporophyll. Figure 5, Pl. 24, shows a transverse view of the upward process of another microsporophyll, × 100. The center of the process is occupied by the small cells which constitute the fibrovascular bundle proper. The bundle is in turn surrounded by a cordon of larger cells with bordered pits—the transfusion elements. Figure 6, Pl. 24, shows an image of some of the microspores, × 500. One of these below the center of the photograph shows a wing with particular clearness on the left, the corresponding right wing is only partially represented. In one of the microspores above and on the right is seen a transverse section through the two wings.

In living Coniferales air chambers occur in only two tribes, the Abietineae and Podocarpineae. In the Abietineae they are confined to the genera, *Pinus, Picea, Pseudotsuga, Cedrus, Abies* and *Pseudolarix* and are absent in *Tsuga* and *Larix*. In the case of one species of *Tsuga,* however, according to Lemon they are sometimes present. In the Podocarpineae all the genera with the possible exception of *Saxegothaea* have winged microspores. There are no other examples among the living Coniferales of winged microspores.

The fact that air chambers occur in the pollen of two groups so widely separated geographically as the Abietineae and Podocarpineae makes it possible that the presence of air cells in the pollen grains of the Coniferales is an ancient character and that in the older representatives of various tribes they may have had a much wider distribution than at present. The structure of the sporophylls in our fossil points strongly to its araucarineous affinities. In neither the Abietineae nor the Podocarpineae, as far as we have observed, do the leaf traces of the sporophylls become surrounded in their upper region by a cordon of transfusion tissue. This feature is strikingly araucarineous. It seems accordingly not unlikely that our fossil belongs to this tribe. This probability is enhanced by the abietineous features of wood structure found in a large number of the araucarineous species described from the Androvette pit. Fliche, in his "Études sur la Flore Fossile de l'Argonne,"[58] has described and figured three species of Cretaceous cones under the new genus *Pseudo-Araucaria*. These are female cones, characterized by the presence of *two* seeds on the cone scale as in the Abietineae and a less profound fusion between the ovuliferous and sterile scales than is found in the genus *Araucaria*. On the whole it appears not improbable that the slender male cones which we have found in the Cretaceous deposits at Kreischerville belonged to a generalized araucarineous type, nearer in the structure of its male sporophylls to the Abietineae than are any of the existing Araucarineae. It may well have been one of the numerous genera with the *Brachyoxylon* type of wood structure, which have been described in the foregoing pages.

Locality: Androvette pit. Collected by E. C. Jeffrey and Arthur Hollick. Specimens in Jeffrey collection, Cambridge, Mass.

Strobilites Davisii sp. nov.

Plate 3, fig. 10

Cone linear-elliptical in outline, about 5 cm. in length by 2.5 cm. in width at the middle; scales numerous, relatively thin, closely imbricated.

This is the most perfect cone thus far obtained from the Kreischerville deposits, and it more or less resembles certain Cretaceous cones

[58] Bull. Soc. Sci. Nancy II. 14: 70–84. *pl. 6. f. 3, 3', 4; pl. 7. f. 1, 2.* 1896.

elsewhere described and figured.[59] Unfortunately the condition of the specimen was such that it could not be sectioned for microscopic examination, so that its true generic or tribal relationship could not be determined. For this reason it is placed in the comprehensive genus *Strobilites* and a specific name given to it in honor of the discoverer, Mr. William T. Davis. It is in all probability, generically at least, identical with Fontaine's *Abietites angusticarpus* (*l. c.*), but inasmuch as this name more or less definitely implies relationship with the Abietineae, it was not thought advisable to so refer it as long as any doubt remains as to its identity.

Locality: Drummond pit. Collected by William T. Davis. Specimen in Mus. Staten Island Assoc. Arts and Sci.

STROBILITES sp.

Plate 3, fig. 9

This specimen is little more than an impression in the clay and the determination of its generic or tribal relationship is not feasible. It is possible, however, that it may belong with some of the so-called *Sequoia* cones which are found more or less abundantly in the Cretaceous deposits of New Jersey, or, more probably, it may represent one of the species of cones from which some one or another of the scales described in this Memoir were derived and hence no distinctive specific designation is here attempted.

Locality: Androvette pit. Collected by Arthur Hollick. Specimen in Mus. Staten Island Assoc. Arts and Sci.

[59] *Araucarites Goepperti* Presl, in Sternb. Verst. 2: 204. *pl. 39. f. 4.*
Pinus protopicea Vel. Gymnosp. Böhm. Kreideform. 31. *pl. 7. f. 4.*
Abietites angusticarpus Font. Monog. U. S. Geol. Surv. 15 (Potomac or Younger Mesoz. Fl.): 263. *pl. 133. f. 1.*

CONCLUSIONS

The many new facts in regard to the internal structure of Cretaceous conifers, described in this Memoir as the result of our studies of the plant remains from the deposits at Kreischerville, must inevitably have a more or less important bearing on the question of the evolution of the conifers in general and particularly the relationship of the Araucarineae to the other tribes of the Coniferales. This must follow whether our reference of certain branches and cone scales to recognized Cretaceous genera, known previously from impressions alone, is accepted or not. Thus, even if it be denied that the branches and cone scales we have described as belonging to or closely related to the genus *Geinitzia* are recognized as such or not by other students of Cretaceous plants, it nevertheless results that a very marked superficial resemblance to a well-defined and characteristic sequoiineous type, both in the habit of the leafy twigs and in the superficial appearance of the cone scales is entirely illusory, since the structure of these remains shows them to be unquestionably araucarineous. The conclusion must further be inevitably drawn from our observed facts in regard to this extensive Cretaceous coniferous flora, that the superficial appearance of conifers of this period is in general of very slight value in determining their actual botanical affinities, and that even the reproductive organs, *i. e.*, cones and cone scales, of Cretaceous conifers, cannot always be regarded as conclusive evidence of relationship, since these are externally sometimes as deceptive as to their true affinities as are the leafy twigs.

Unless it be assumed that the Kreischerville flora is entirely unique and exceptional, a conclusion quite unwarranted by the nature of the impressions associated with the remains with structure preserved, its composition and the affinities of the forms represented must be of considerable importance from the evolutionary standpoint. It may be stated in general that there are present in these beds conifers resembling, either in their general habits or in their reproductive organs (external features) or in both, the Sequoiineae (***Brachyphyllum**, **Geinitzia**, **Eugeinitzia**, **Pseudogeinitzia**, **Anomaspis**, **Sphenas-***

pis), the Cupressineae (*Widdringtonites, Thuites, Raritania, Dactylolepis*), and the Podocarpineae (*Androvettia*), all of which are in reality not related to the tribes which they simulate but to the Araucarineae. While it might be possible to doubt the evidence for araucarineous affinities on the basis of the structure of either the leafy twigs or the cone scales alone, it appears quite impossible to question the independent and consonant evidence afforded by a study of the anatomy of both.

If it be admitted that these remarkable genera represent an araucarineous flora the question arises as to their affinities. Attention has been repeatedly called in the earlier part of this Memoir to the common *Brachyoxylon* type of wood possessed by this group of conifers, which differs, as we have defined it, from *Araucarioxylon* Kraus by the fact that the pitting is not strictly and uniformly araucarineous, but presents a transition towards the condition found in the Abietineae and other conifers. It also presents the further peculiar feature of having a characteristic type of wound reaction found in the Abietineae but not in the existing genera of the Araucarineae, which feature apparently indicates a transitional type of wood. Another type of araucarineous wood is also found in the Kreischerville deposits, which possesses all of the araucarineous features found in *Brachyoxylon,* but shows an even closer affinity than the latter to the Abietineae, by the possession of the abietineous type of the medullary ray. To this type *Araucariopitys* belongs. Here not only the lateral walls of the ray cells are pitted but also the horizontal and terminal walls, as is the characteristic condition of the rays in the Abietineae. Since in *Brachyoxylon* and *Araucariopitys* we have Mesozoic types of araucarineous wood, which both by their structure and wound reactions connect the existing type of araucarian wood (as well as *Araucarioxylon* Kraus) with that which is characteristic of the Abietineae, the question naturally arises, whether the *Araucarioxylon* or *Pityoxylon* (abietineous) type is the more primitive. It is practically universally assumed at present, from the resemblance of the pitting found in araucarian woods to that found in the Cordaitales and other ancient types of gymnosperms, that the Araucarineae represent the oldest conifers. Without considering the argument for the primitive character of the Araucarineae, based on the supposed presence, in the case of the female cone of *Araucaria* of a ligular structure, comparable to that

found in the heterosporous Lycopodiales, an argument which may now be considered as having very slight support since it has been abandoned even by Professor Seward, the latest and most vigorous defender of the lycopodineous origin of the Araucarineae, we may proceed to examine the grounds for deriving the Araucarineae directly from the older gymnosperms with crowded radial pitting of the tracheids.

In the first place it should be pointed out that the nature of the ligneous pitting alone cannot serve satisfactorily to establish relationships, since in that case the angiosperms and Gnetales must both be connected directly with the older gymnosperms, because they usually possess the same alternate type of pitting and *Gingko,* which shows so many primitive characters, must be allied with the Abietineae, since it shares with these the feature of opposite non-alternating pits and the even more striking character of the bars of Sanio. As has been pointed out by Kraus, the kind of pitting found in the living Araucarineae and in *Araucarioxylon* Kraus, presents this general feature of difference from that found in the Cordaitales, etc. —that the bordered pits are for the most part crowded in the ends of the tracheids and do not cover the entire radial walls of the water-conducting elements.

The wound reactions of *Brachyoxylon* and *Araucariopitys* constitute a strong objection to the derivation of the Coniferales through the Araucarineae from the older gymnosperms. It has been pointed out by the junior author[60] that the type of abietineous wood, characterized by the presence of resin canals in the mature secondary wood as the result of injury only, is less ancient than that in which the resin canals are a normal feature of the secondary wood, as is shown by the greater geological age of the abietineous type with normal resin canals in the wood, and by the fact that in accordance with the theory of recapitulation those Abietineae which do not normally possess resin canals in their secondary wood often show them in the first year's growth. The greater antiquity of those Abietineae, which, like *Pinus,* have resin canals normally present in the secondary wood, further seems to be placed quite beyond question by the discovery of structural remains of the ancient abietineous type, *Prepinus,* in which the leaves are characterized by a structure of the fibrovascular bundles identical in general organization

[60] Mem. Boston Soc. Nat. Hist. 6: 5. 1905.

with that found in certain Cordaitales. If the occurrence of resin canals as a result of wounding in the wood of those more modern Abietineae (*Cedrus, Abies, Tsuga, Pseudolarix*), which are normally without resin canals in the secondary wood, is to be regarded as a reversionary phenomenon, as it apparently must be, in view of all the evidence now at our disposal, it involves no distortion of logical principles to regard the traumatic resin canals of *Brachyoxylon* and *Araucariopitys* as likewise reversionary features. Since the possession of ligneous resin canals is a very ancient characteristic of the Abietineae, recorded by Goeppert as far back as the Carboniferous of Waldenburg, it is highly probable, on the basis of the evidence of traumatic resin canals, that the *Brachyoxylon* and *Araucariopitys* types of wood are as truly derived from that of the older Abietineae as is the *Cedroxylon* type of Kraus found in the more modern Abietineae (*Cedrus, Abies, Tsuga,* etc.). It may accordingly be considered as highly probable that the Araucarineae possessed of the *Brachyoxylon* and *Araucariopitys* type of wood are more or less closely related in their origin to the ancestral stock of the Abietineae.

Further, the free ovuliferous scales found in the female cone of the Abietineae corresponds according to the weight of evidence in a general way to a reduced branch, axillary to the subtending so-called sterile bracts. In the Araucarineae, as is specially well shown in some of the fossil species described structurally in this Memoir, we have instead of the two separate scales a complex organ made up, if we may judge from the double nature of the persisting fibrovascular structures, of two scales, ovuliferous and sterile, such as are found in the Abietineae, congenitally fused together. If the fusion of ovuliferous and sterile scales be admitted for the Araucarineae, and it can scarcely be denied in view of the strong degree of approximation of the wood structure of the older Araucarineae to that of the Abietineae, as described in this Memoir and exemplified by the *Brachyoxylon* and *Araucariopitys* types of wood, it follows that the tribe of conifers which presents the ovuliferous scale in the free condition, viz., the Abietineae, is the older.

But the strongest evidence in favor of the correctness of our view is furnished by the leaf structure of Cretaceous pines, which present a more archaic type of foliar bundle than is found in those species of *Pinus* now living. In the genus *Prepinus* the archaic characters of the leaf-bundle are most strongly marked of all, for

here is found true centripetal wood and a general organization of the transfusion tissues, similar to that present in certain Cordaitales.

On the basis of the lines of argument derived from a consideration of the structure of the wood and of its wound reactions in *Brachyoxylon* and *Araucariopitys;* of the structure of the ovuliferous cone scales of recent and Cretaceous Araucarineae and of the archigymnospermic type of leaf-bundle found in Cretaceous pines, and preeminently in *Prepinus,* we conclude that the type of araucarian characteristic of the Kreischerville flora is more ancient in its affinities than the araucarineous stock represented by the living *Agathis* and *Araucaria,* and was clearly derived from abietineous ancestry and particularly from forms closely allied to the living genus *Pinus.*

It will probably be urged by advocates of the araucarineous origin of the Coniferales that the comparatively slight representation of the abietineous stock in the Mesozoic is against their having been the progenitors of the modern groups of Coniferales. That the Abietineae were really scantily present in the Mesozoic flora is, however, open to question. In the Kreischerville deposits we have found remains of at least seven distinct species of *Pinus* and one species of *Prepinus.* It would be difficult at the present epoch to gather the water-borne relics of seven species of *Pinus* in the same resting place, except, perhaps, in a stream issuing from the pinetum of a botanical garden, and this in spite of the fact that there are some ninety species of the genus now in existence. There is accordingly no good reason to suppose that *Pinus* was not quite as well represented by species in the middle Cretaceous as it is at present. Even if we admit that the Abietineae were less numerous in the Mesozoic than at present, it appears to be a fallacious conclusion that on that account they were necessarily less primitive than the apparently more prevalent Araucarineae. It would not be less reasonable to suppose that the richly branched and leafy crown of a tree is its oldest portion. It is highly probable in view of the various facts described in this Memoir that the Araucarineae actually did represent the abundant crown of the coniferous genealogical tree in Mesozoic time, but that by their almost complete extinction in the important changes which ushered in the Tertiary period, a lower, more ancient and overshadowed branch, the Abietineae, became a new "leader" and in its subsequent development very much obscured the original plan of phylogenetic development. The validity of this conclusion will be strengthened when certain experimental results, obtained by one of us in the case

of the more modern tribes of conifers have been published. It may be stated in general that the abundance of araucarineous or any other plant remains at earlier periods of the earth's history does not necessarily supply evidence of superior antiquity.

Whether the arguments advanced above for the derivation of the Araucarineae from a stock closely allied to the still flourishing but very ancient genus *Pinus*, be accepted or not, it is quite clear that a large part of the coniferous flora of the Cretaceous and probably earlier periods, was composed of types of araucarians, differing markedly in their wood structure, their wound reactions and general organization from the existing genera *Agathis* and *Araucaria* and their near relatives of the Mesozoic.

In accordance with the facts thus far determined in regard to the structure of recent and fossil araucarineous woods, the Araucarineae may be separated in three sub-tribes as follows:

ARAUCARIOPITYOIDEAE

Wood tracheids with both araucarineous and abietineous pitting, the araucarineous pitting ordinarily confined to the ends of the tracheids. Traumatic resin canals resulting from injury often present. Medullary ray cells with abietineous pitting, *i. e.*, with pits on the horizontal and terminal walls of, as well as on those in contact with, the tracheids. Leaves probably occurring on short shoots as in *Pinus*. Reproductive organs not accurately known (*Araucariopitys*, *Czekanowskia* (?)).

BRACHYPHYLLOIDEAE

Wood tracheids with both araucarineous and abietineous pitting, the araucarineous pitting confined to the ends of the tracheids. Traumatic resin canals may be formed as the result of injury. Medullary ray cells with araucarineous pitting, *i. e.*, the walls smooth except those in contact with the tracheids. Leaves not occurring on short shoots, various. Scales of the female cones various, peltate to squamiform, persistent or deciduous (*Brachyphyllum*, *Geinitzia*, *Raritania*, *Widdringtonites*, *Thuites*, *Androvettia*, etc.).

ARAUCARIOIDEAE

Wood tracheids with araucarineous pitting (radial bordered pits alternating or flattened by mutual contact). Traumatic resin canals

not formed. Rays strictly araucarineous, with pits on the walls in contact with the tracheids only. Leaves not on short shoots, various. Female cone scales squamiform, deciduous (*Agathis, Araucaria, Albertia* (?), *Pseudo-Araucaria* (?)).

It appears probable that the above order of enumeration of the sub-tribes corresponds to their phylogenetic sequence, the Araucariopityoideae being the oldest.

SUMMARY

1. By special means of isolation we have been able to secure from the Androvette and Drummond clay pits at Kreischerville, Staten Island, N. Y., structural material of leafy twigs, cone scales and fragments of lignite, representing a considerable number of important Cretaceous coniferous genera.

2. Some of these remains are genera already known from impressions, others represent genera which are new to science.

3. The coniferous flora of the Androvette pit consists of abundant remains of species of *Pinus* and of other conifers, which have been referred to genera supposed from the habit of their leafy branches, or of their cones, or of both, to belong to the Sequoiineae, the Cupressineae and the Podocarpineae.

4. The conifers referred on their superficial characters to the Sequoiineae, Cupressineae and Podocarpineae, turn out from microscopic examination of their leafy twigs and cone scales to belong to the Araucarineae.

5. They represent a special sub-tribe of the Araucarineae, for which the name Brachyphylloideae is proposed.

6. These conifers are characterized by a special type of wood, which we designate *Brachyoxylon*.

7. The wood structure of the Brachyphylloideae clearly allies them with both the Araucarineae (in the narrower sense) and the Abietineae.

8. There is good evidence that the Araucarineae have come through the Brachyphylloideae from ancestors allied to the Abietineae.

9. The abietineous remains from the Androvette pit belong to the genera *Prepinus* and *Pinus*. The species of *Pinus* are in general more archaic than any living species. *Prepinus* shows features of structure more primitive than those known to exist in any other conifer living or extinct.

PLATES

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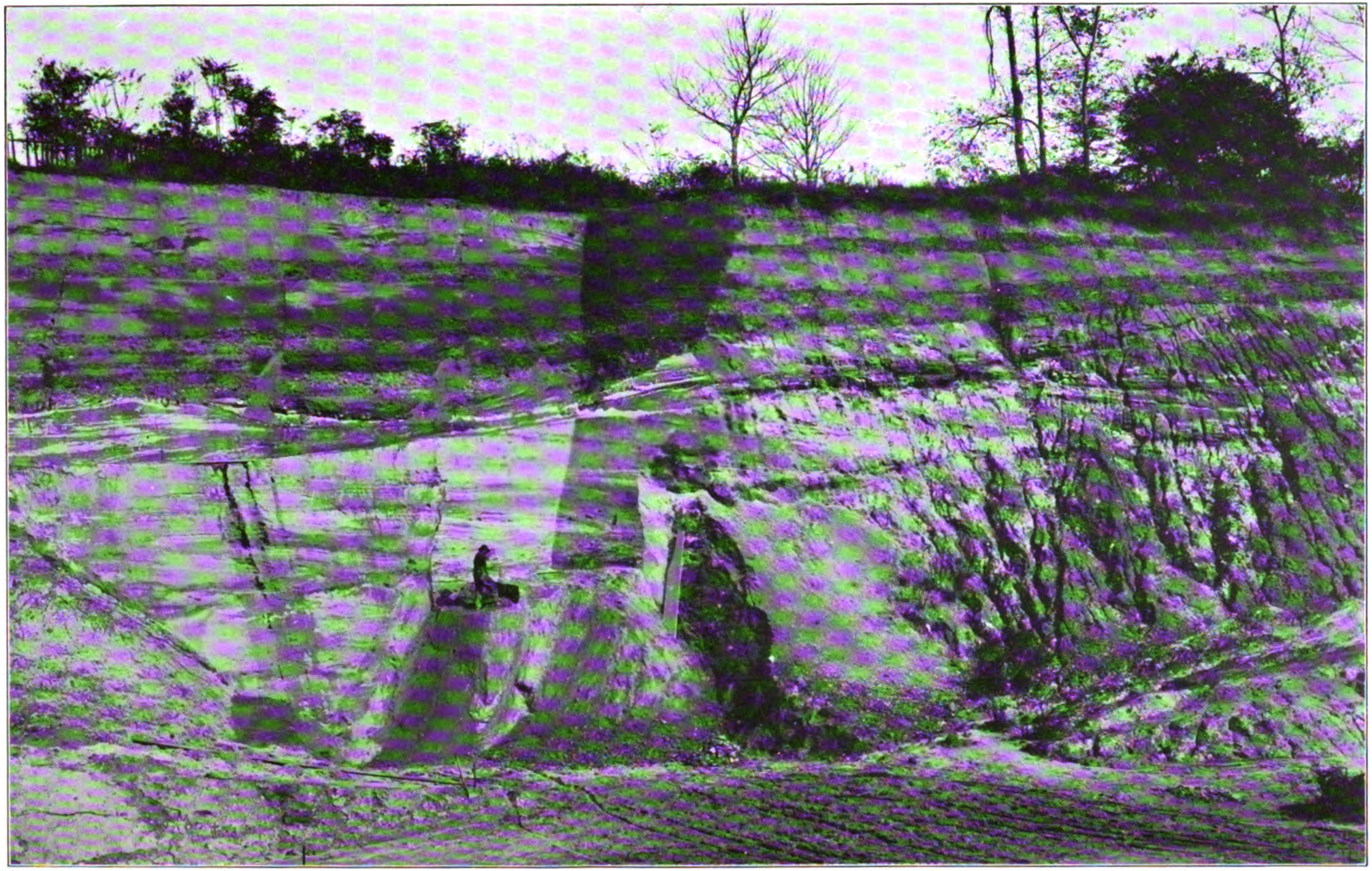
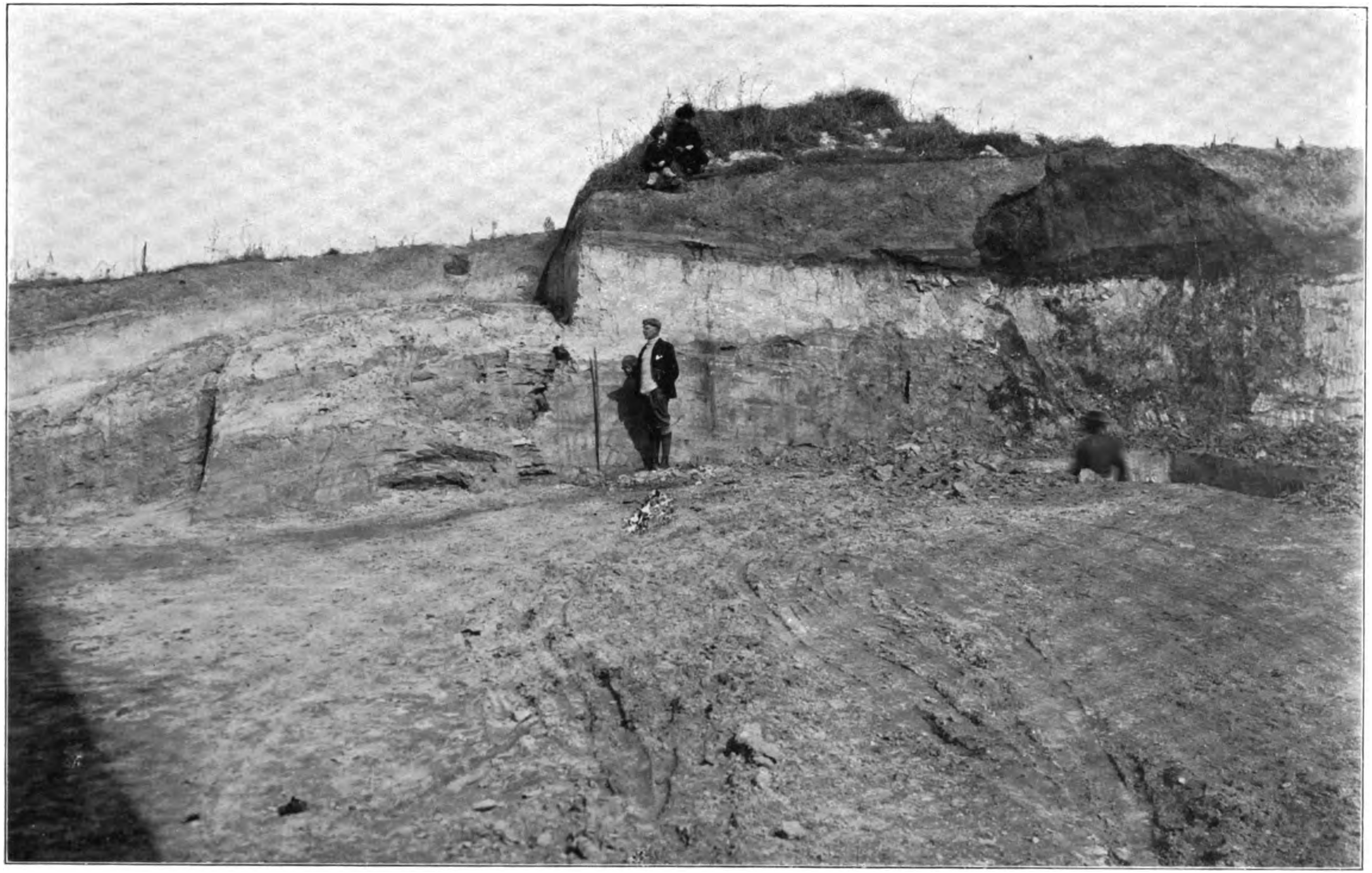
PLATE 1



ANDROVETTE PIT, KREISCHERVILLE, N. Y.

PLATE 2

PLATE 2



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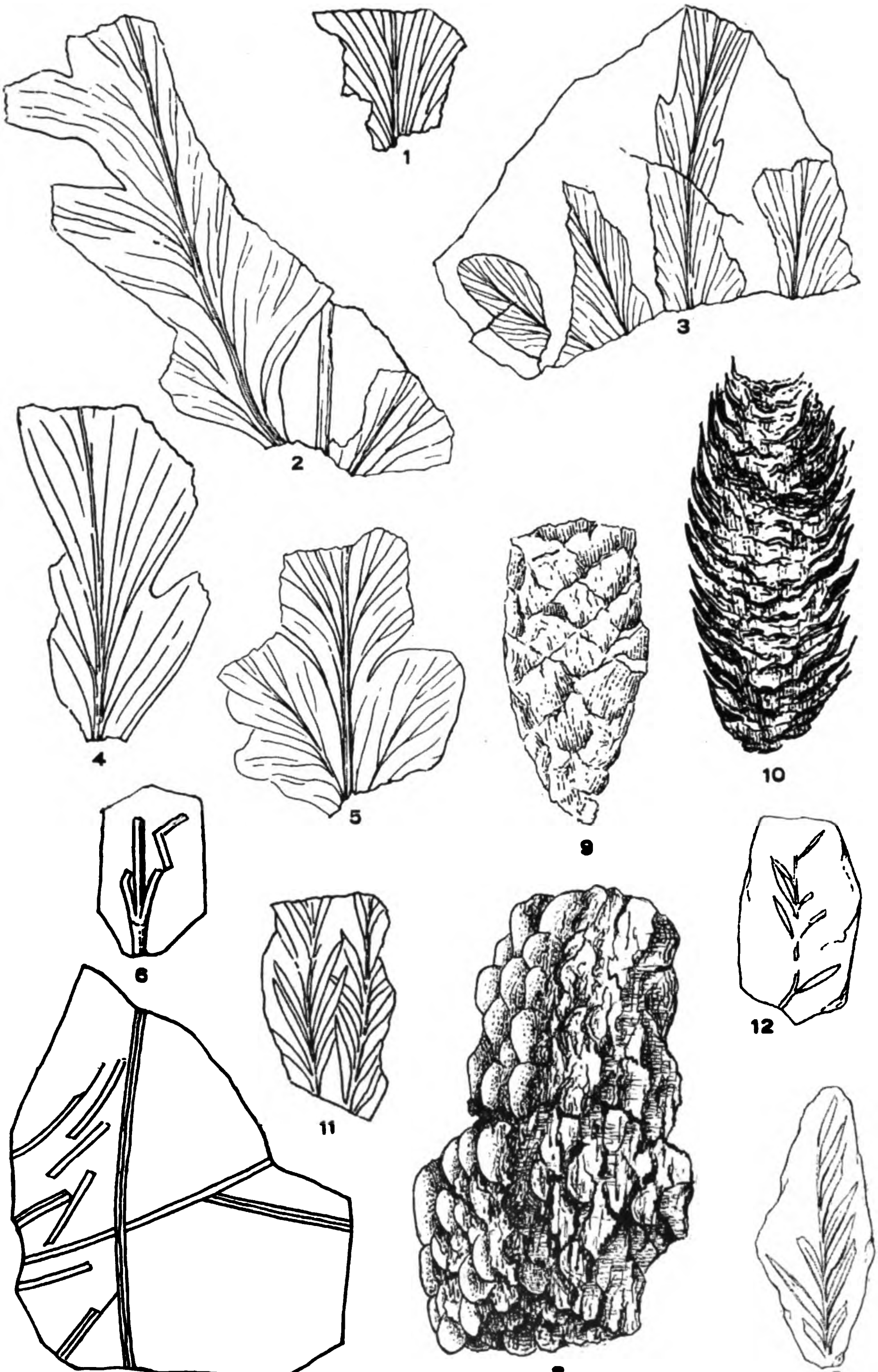

CRETACEOUS CONIFERALES.

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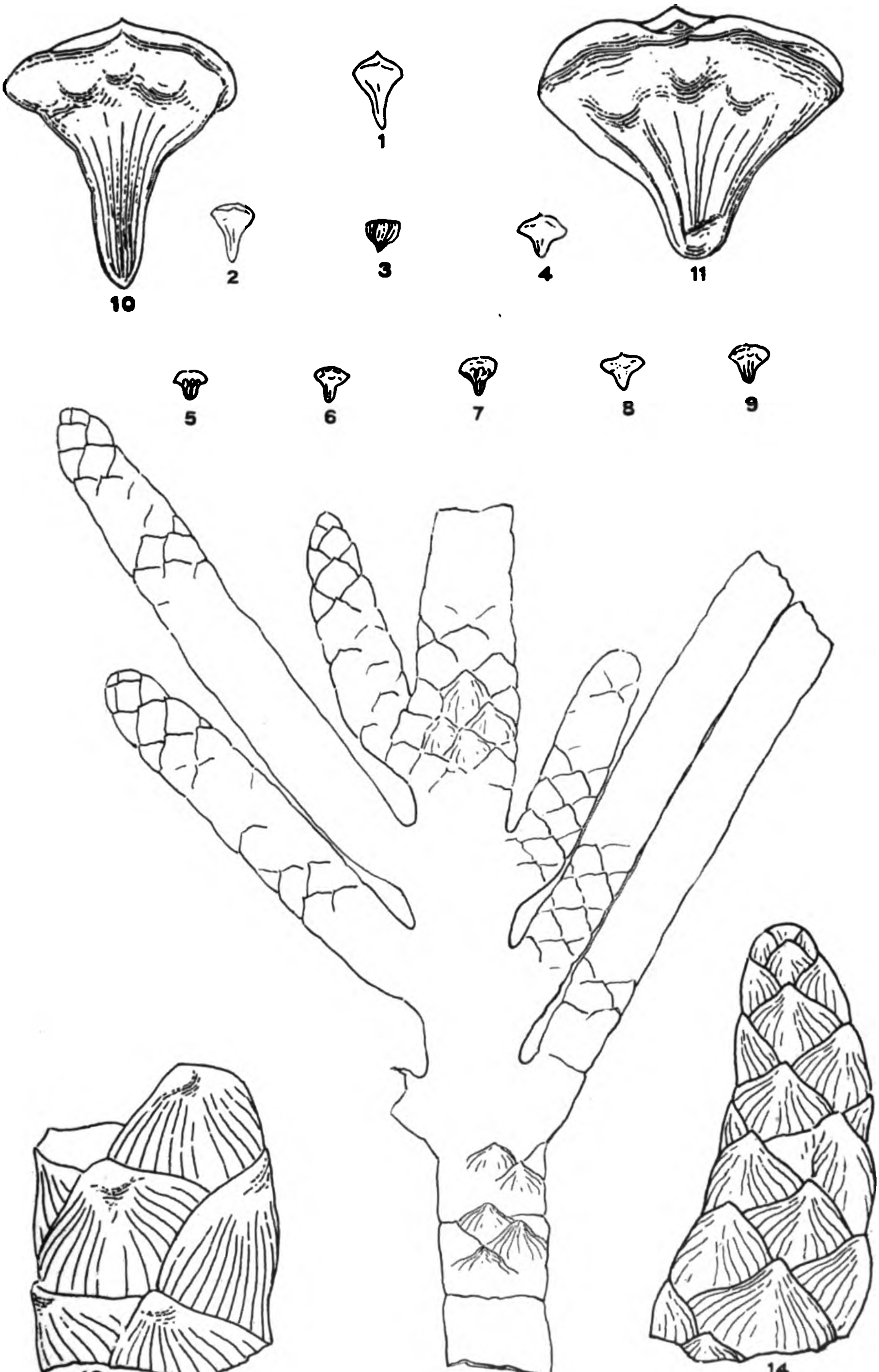

CRETACEOUS CONIFERALES.

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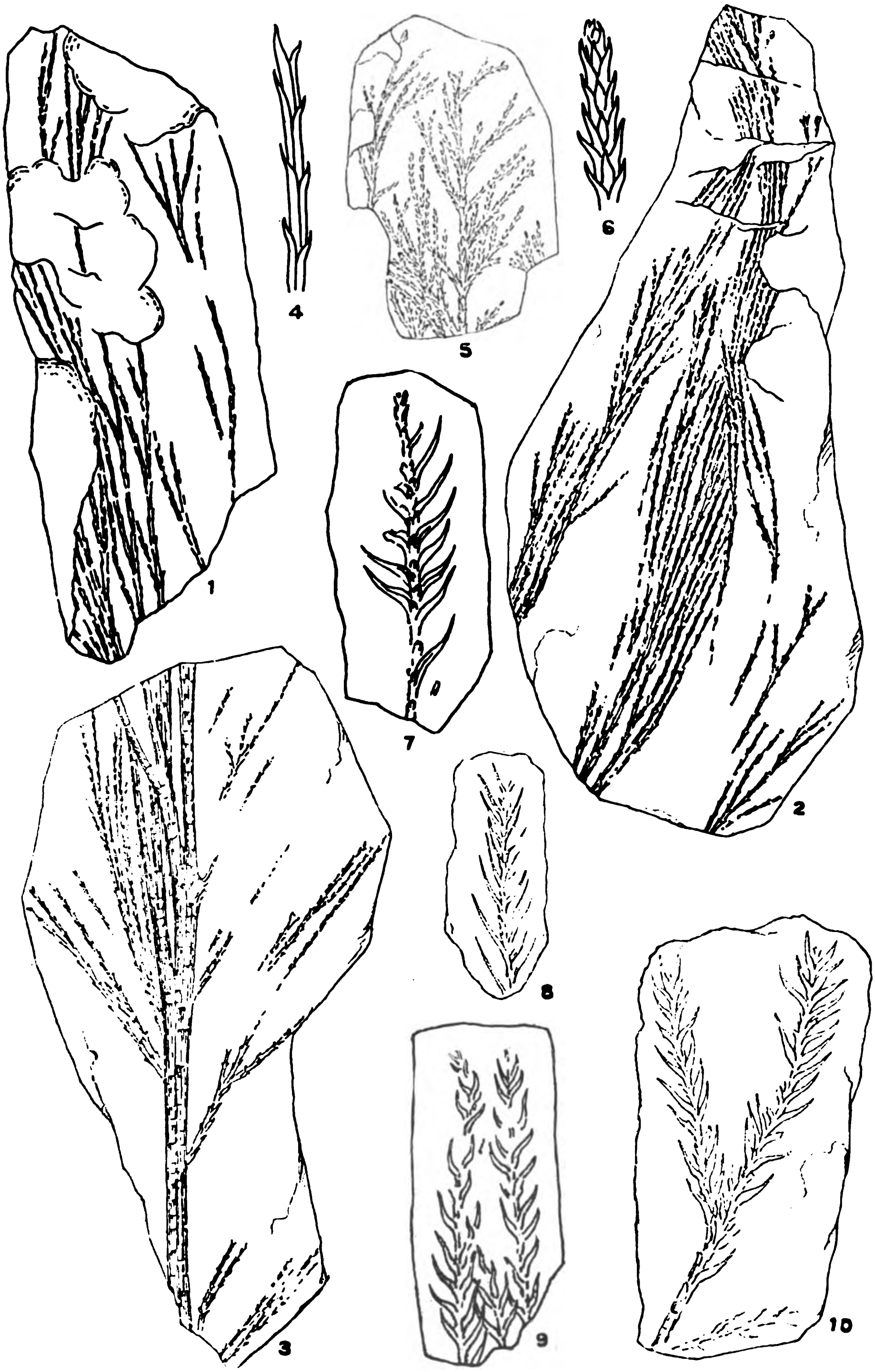

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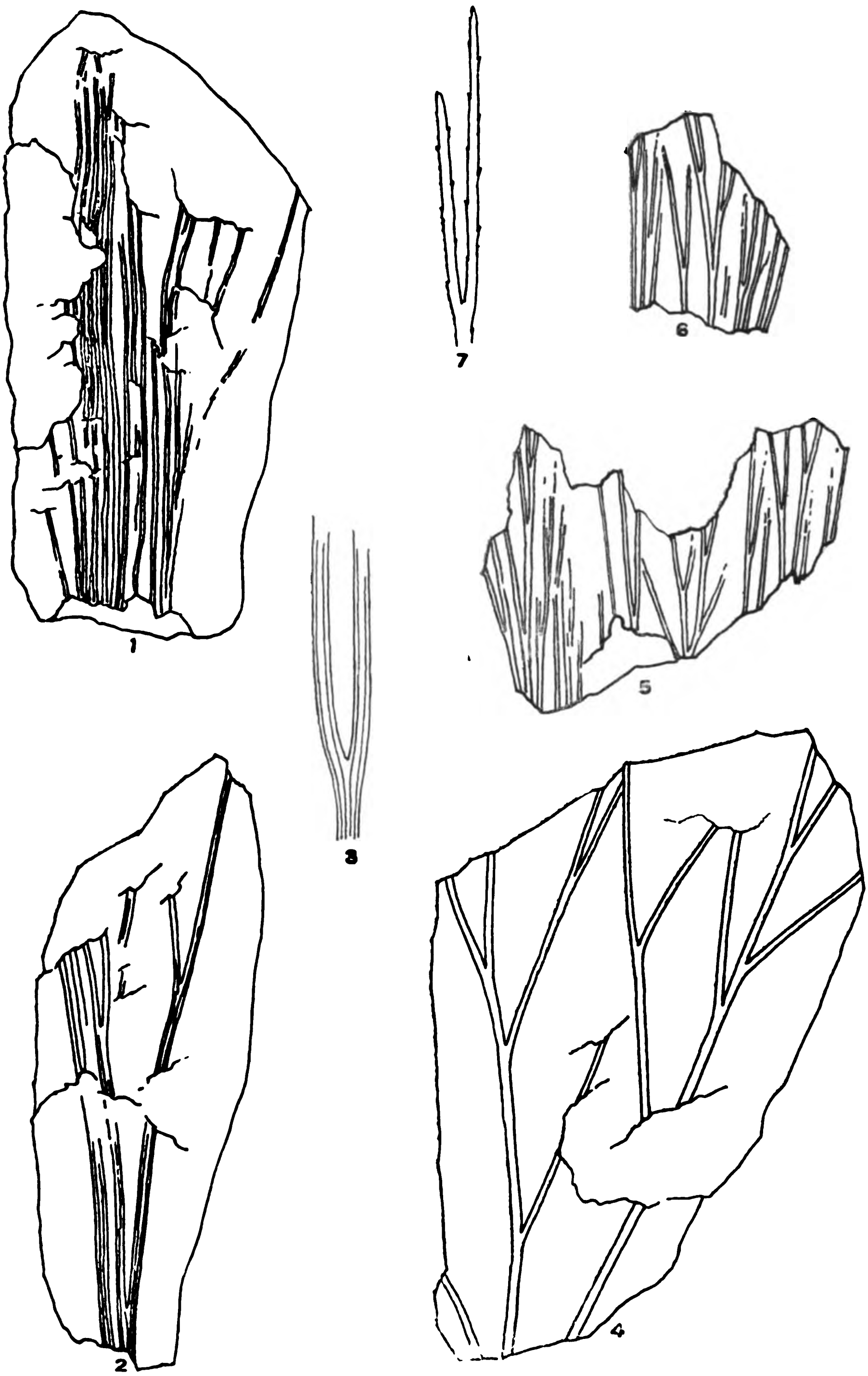

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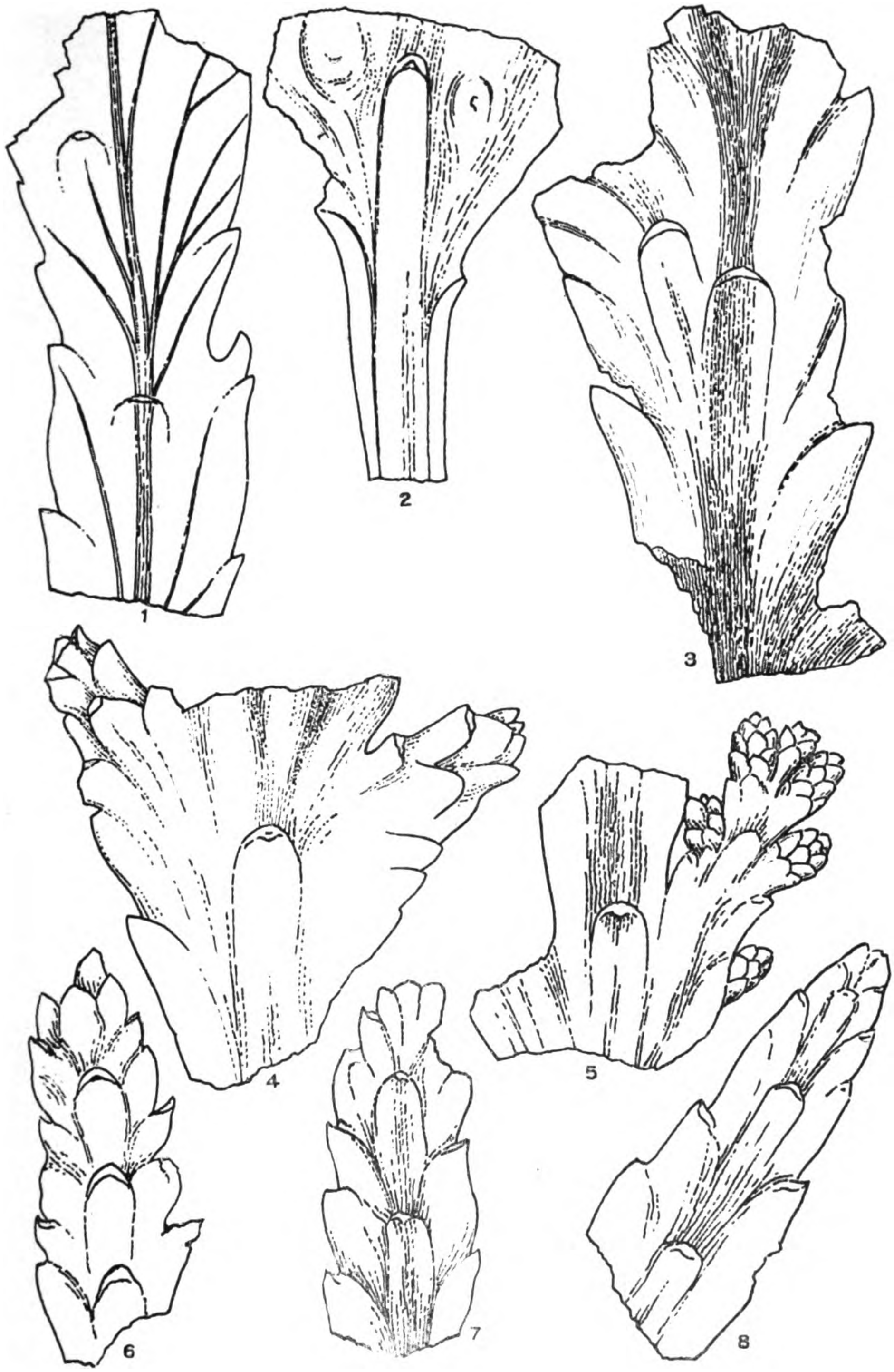

CRETACEOUS CONIFERALES.

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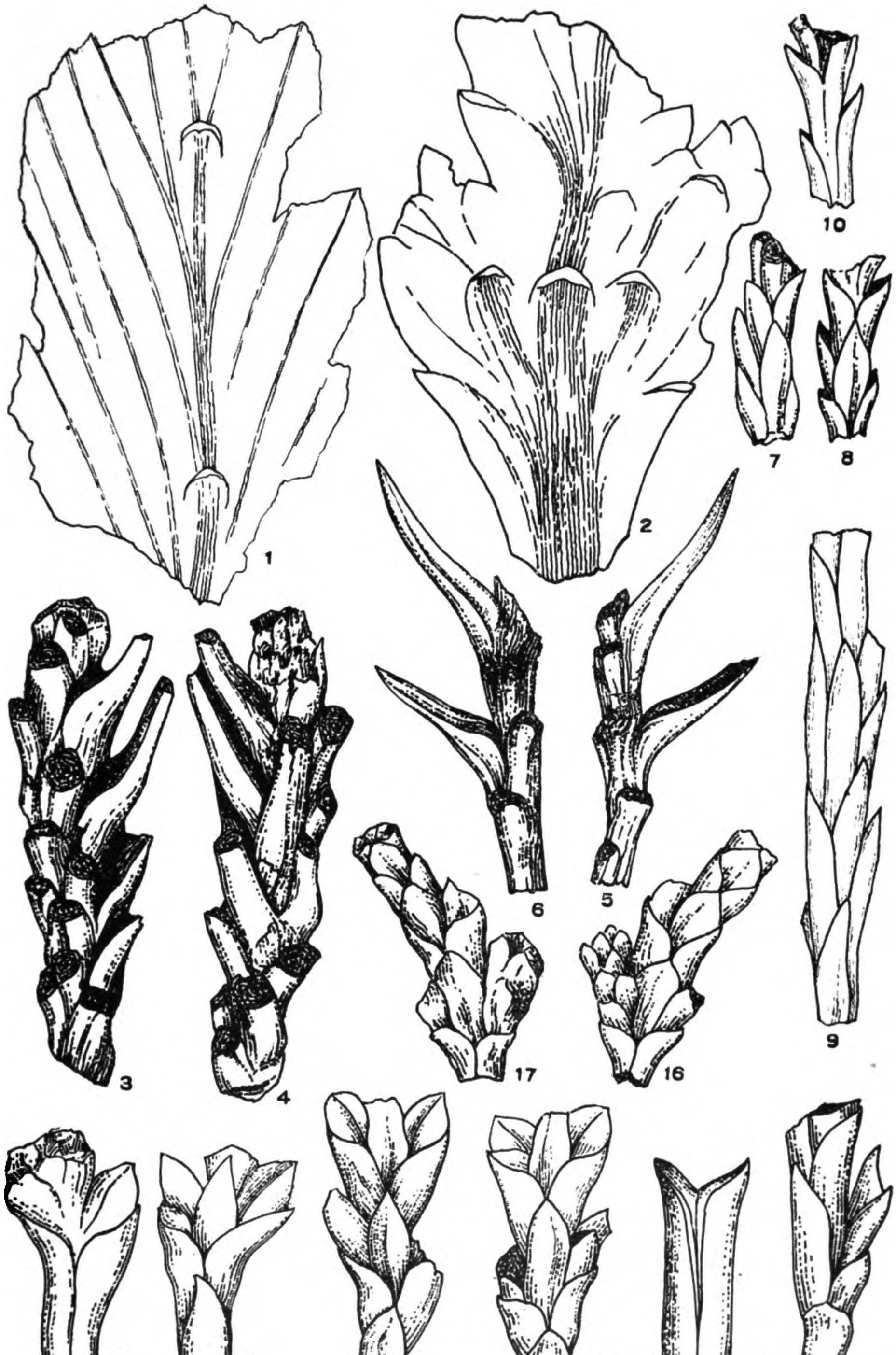

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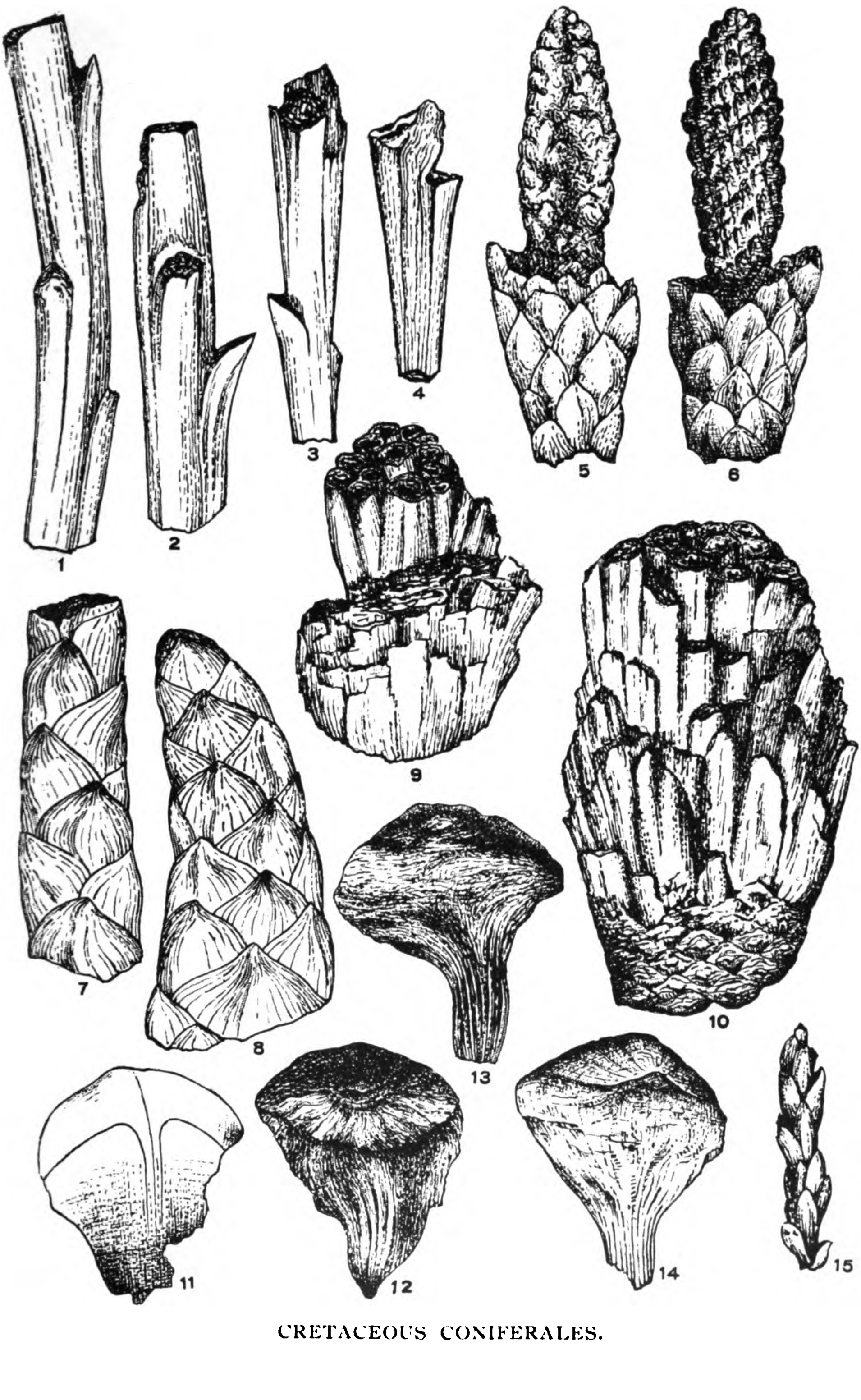

CRETACEOUS CONIFERALES.

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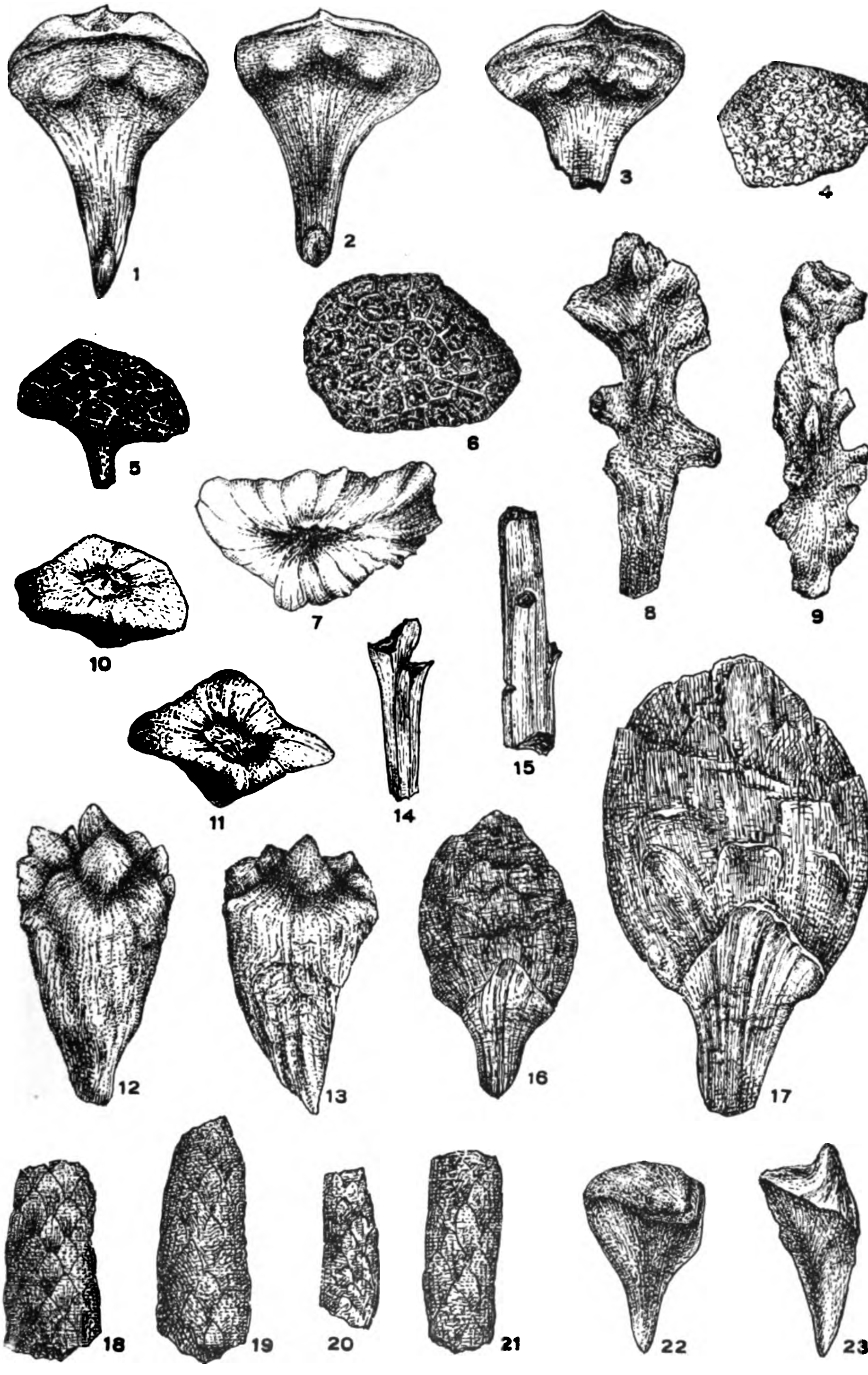
22, 23.	*Sphenaspis statenensis* sp. nov., × 10	51



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Figs. 1, 2, 4, 5. *Brachyphyllum macrocarpum* Newb. 33

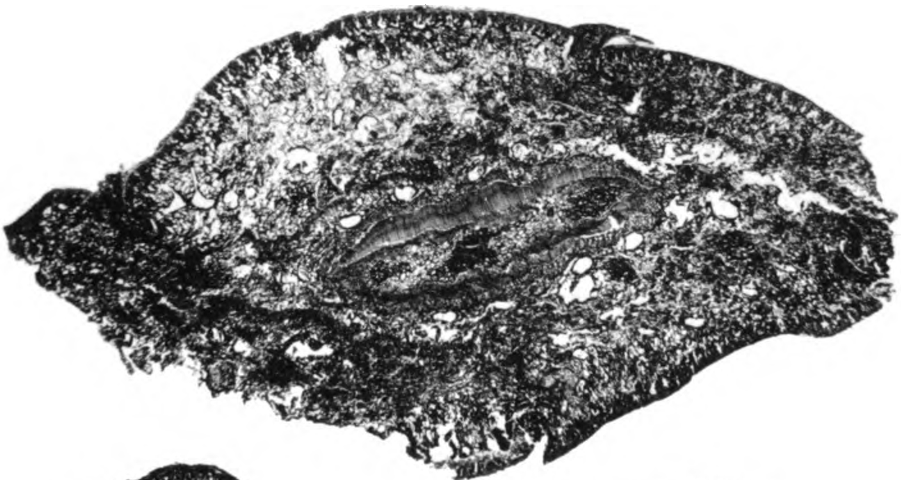
Fig. 1. Transverse section of a branch, × 11.

Fig. 2. Similar section of a smaller branch, × 28.

Fig. 4. Central part of the section shown in fig. 1, × 15.

Fig. 5. Longitudinal section through the center of the branch from which fig. 1 was taken, × 15.

3. Cone of *Brachyphyllum* sp.? Transverse section of the peduncle of the specimen shown in figs. 5, 6, Pl. 9, × 10. 37



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Figs. 1–6. *Brachyphyllum macrocarpum* Newb. 33

Figs. 1, 2. Parts of the transverse section shown in fig. 4, Pl. 11, × 40.

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Fig. 4. Transverse section through a portion of a branch, showing forking leaf-trace, × 40.

Fig. 5. Similar section through the outer portion of a leaf, × 40.

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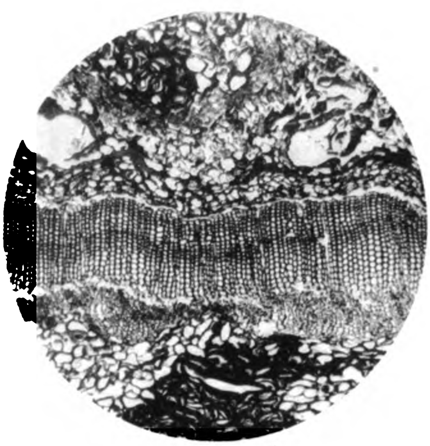

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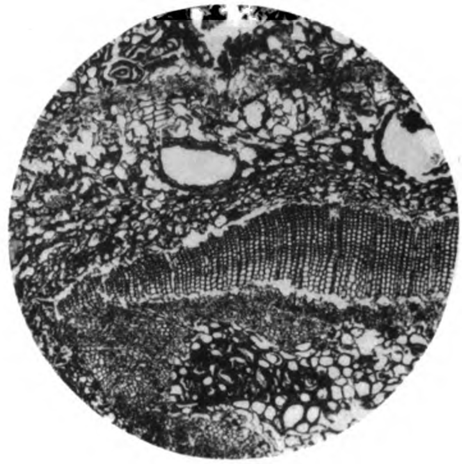

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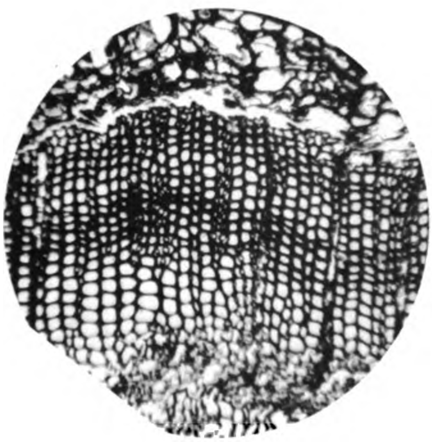

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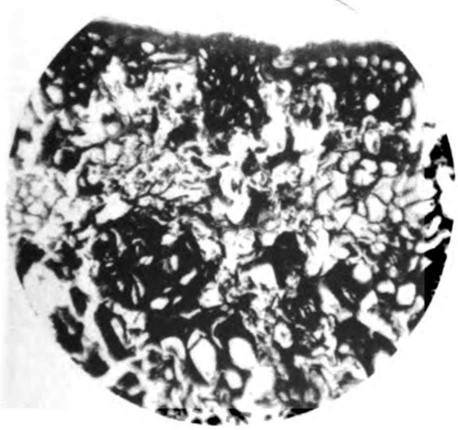

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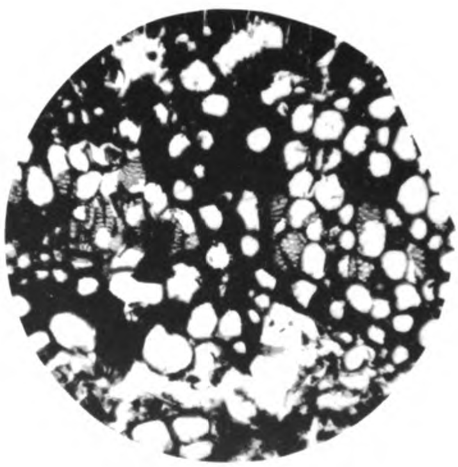

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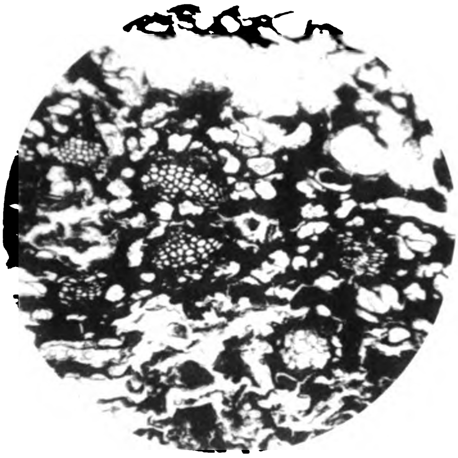
Fig. 2. Transverse section of the wood, × 40.

Fig. 3. Longitudinal section of the same specimen, × 180.

Fig. 4. Similar section of another part of the same specimen, showing flattened pits, × 180.

Fig. 5. Similar section of the same specimen, showing alternation of the pits, × 180.

Fig. 6. Tangential section of the summer wood of the same specimen, showing the tangential pits, × 180.



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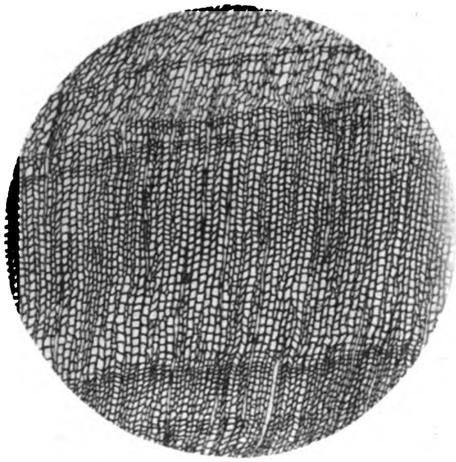

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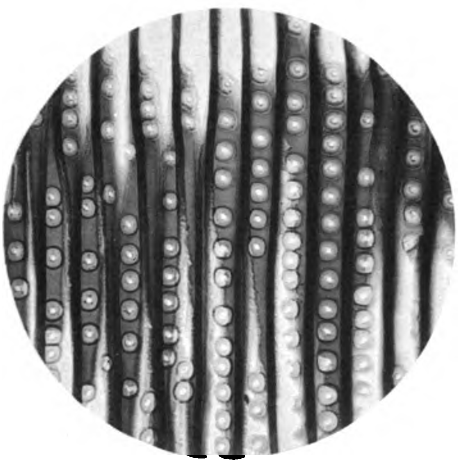

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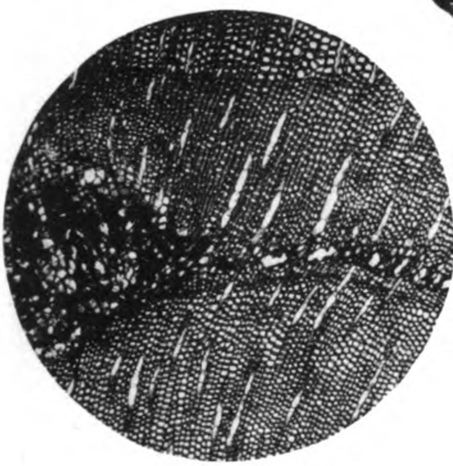

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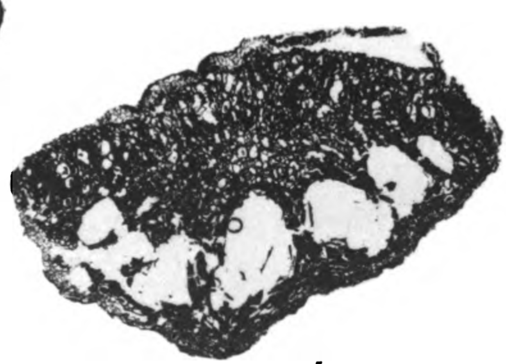

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Fig. 5. Similar section through the median part of a scale, × 40.

Fig. 6. Similar section through one of the bundles of the lower series, showing the surrounding transfusion tissue, × 180.

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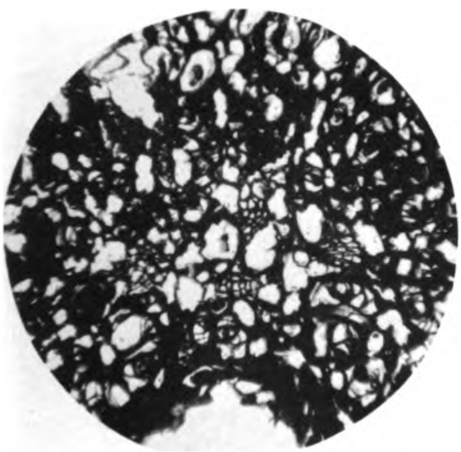

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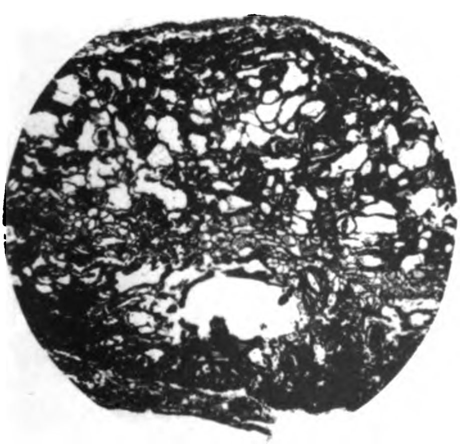

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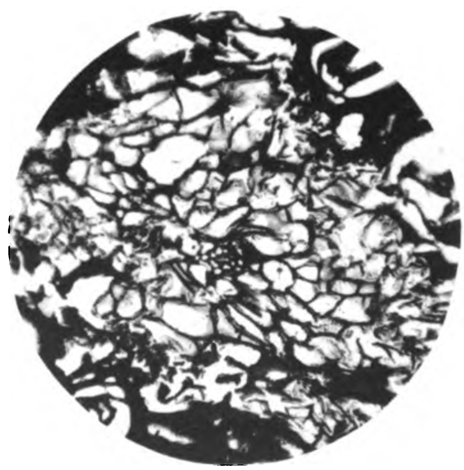

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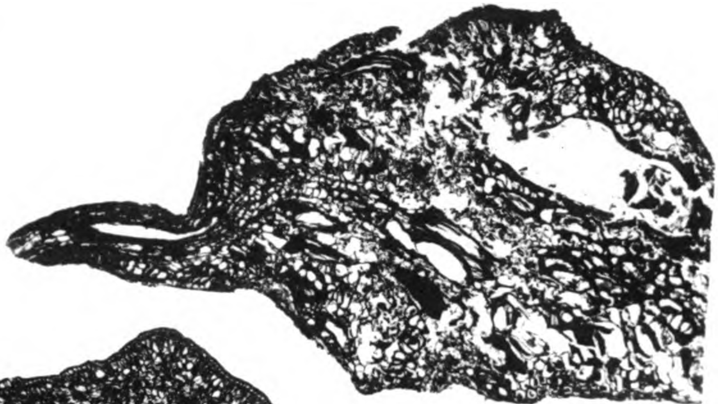

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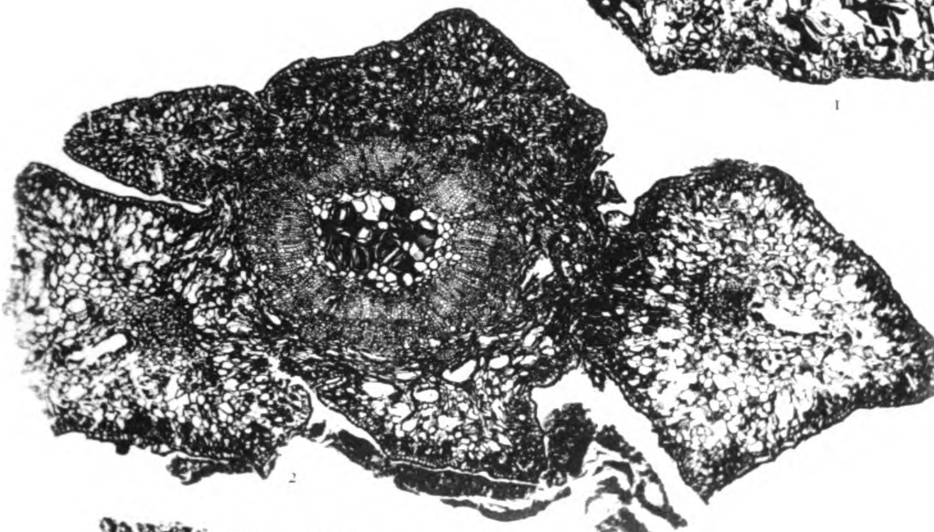

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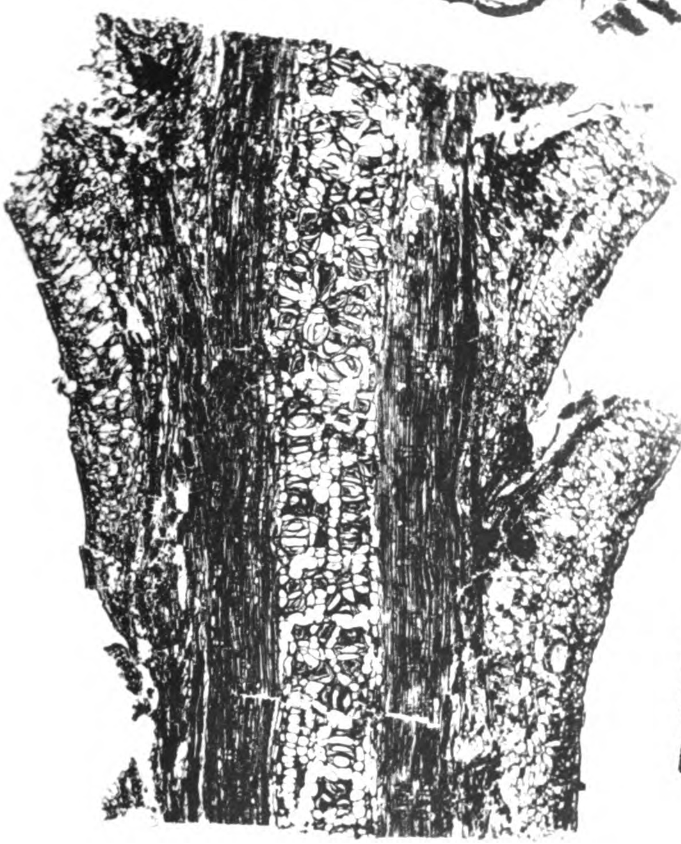

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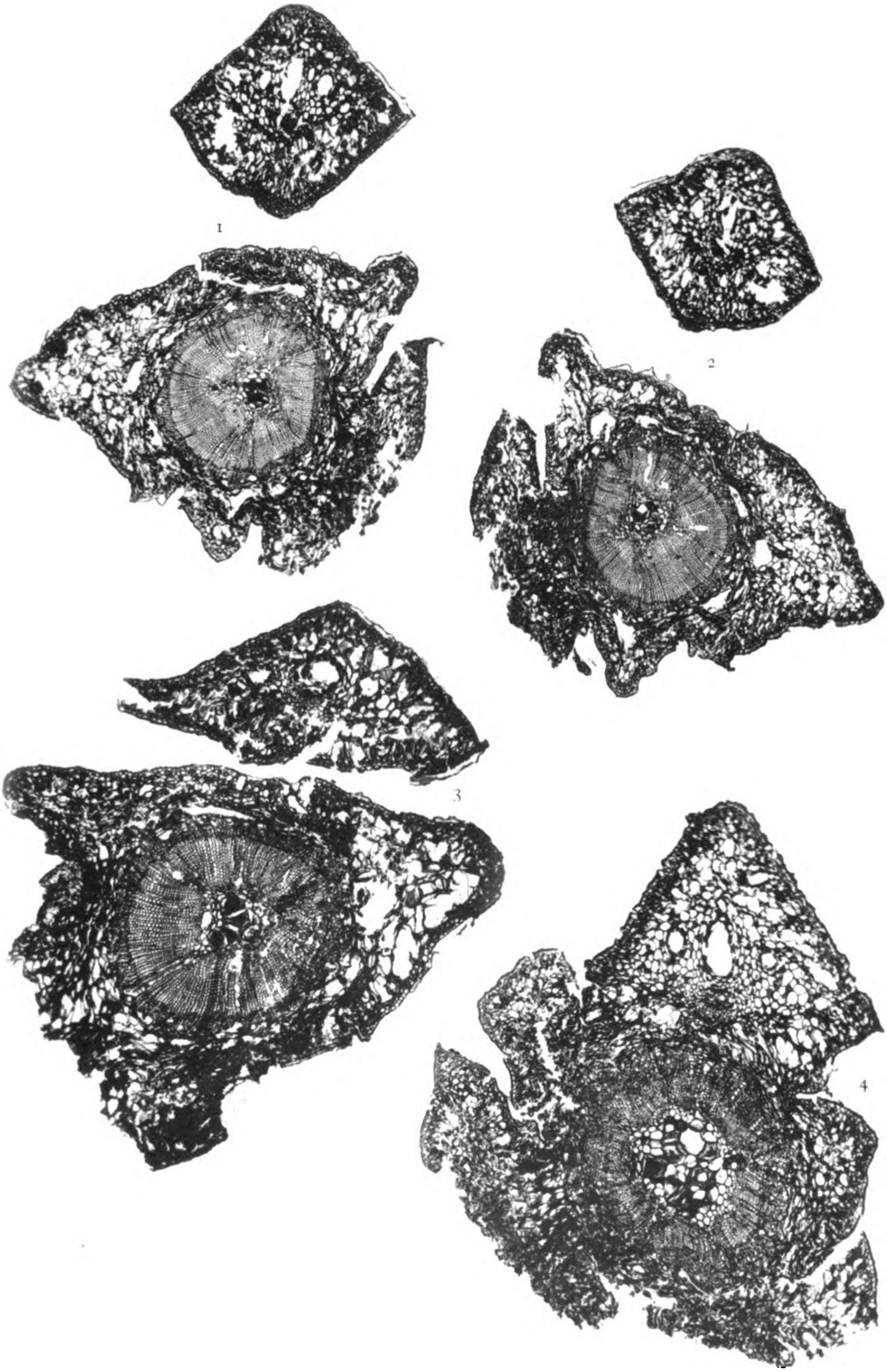

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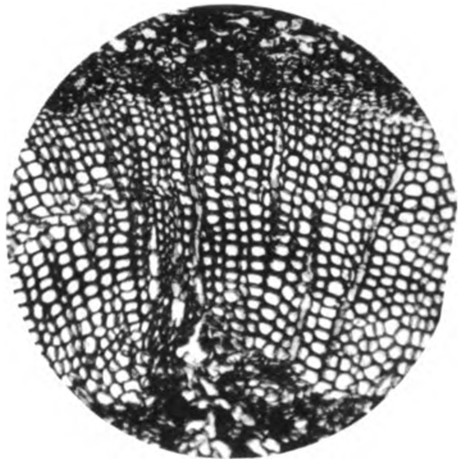

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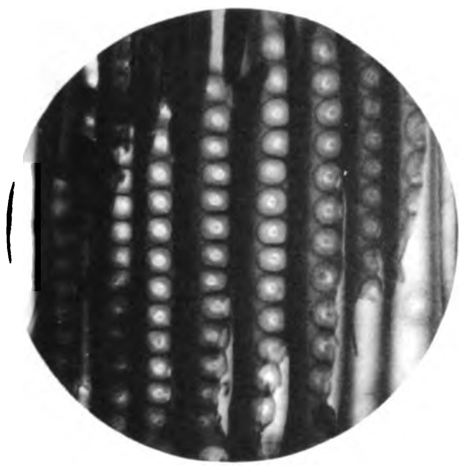

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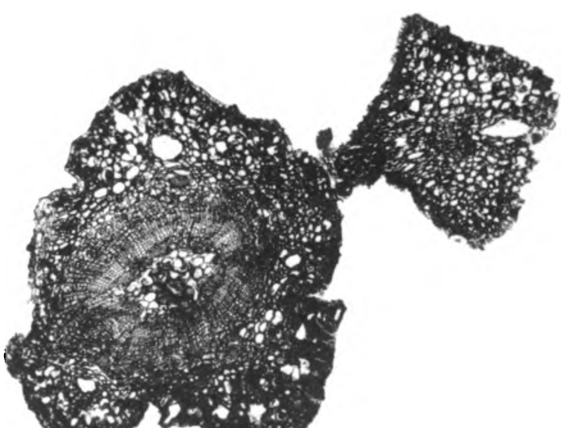

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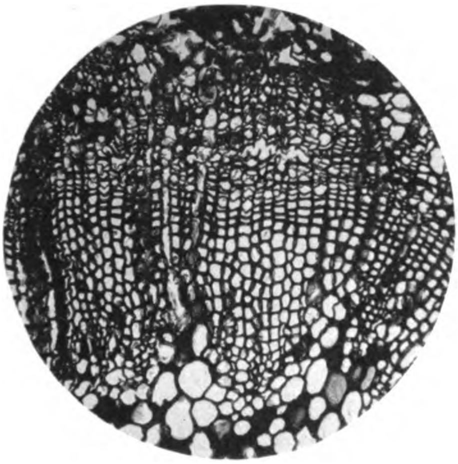

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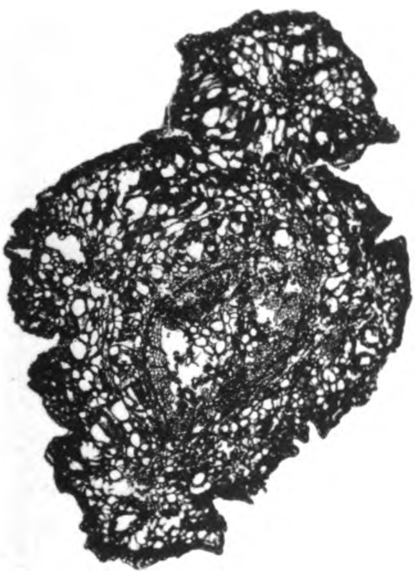

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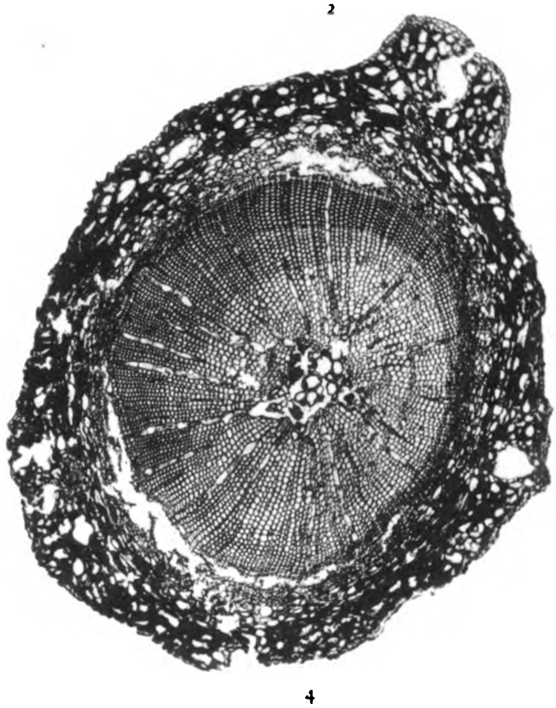

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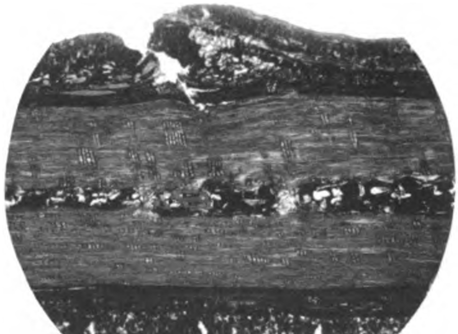

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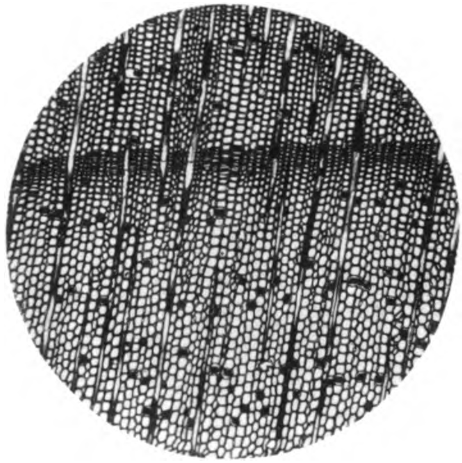

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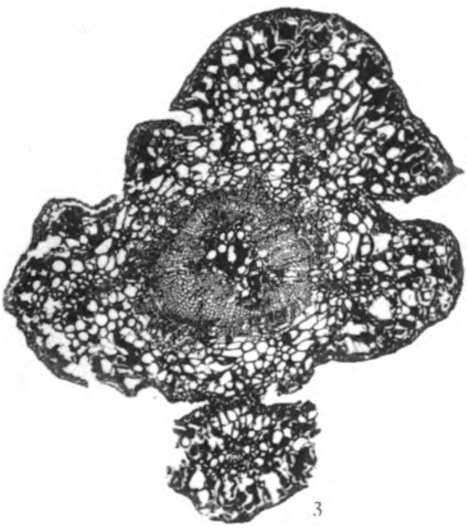

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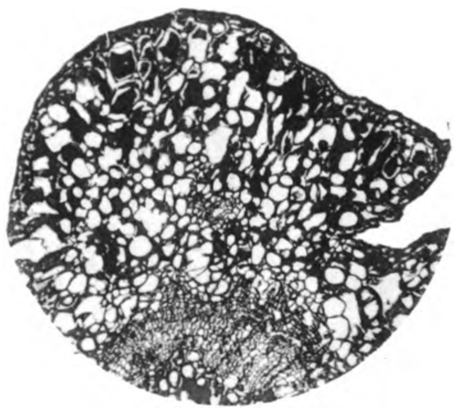

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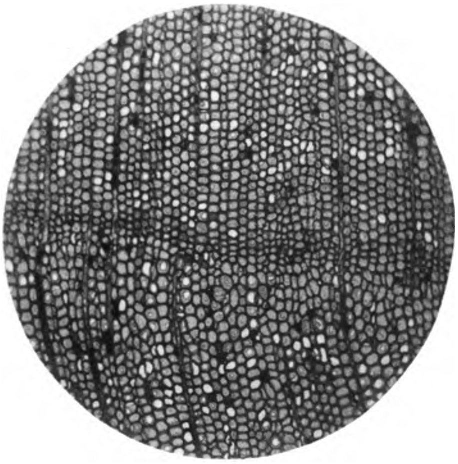

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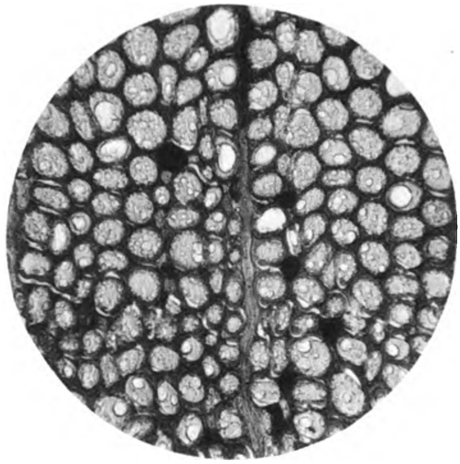

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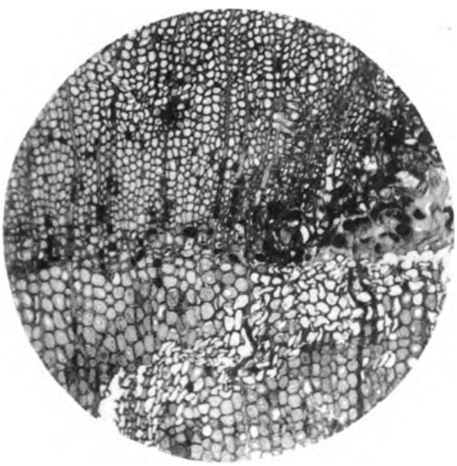

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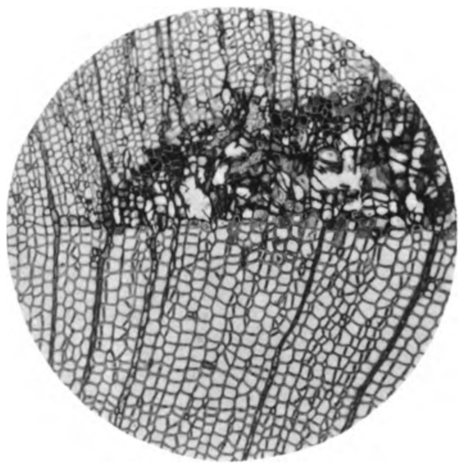

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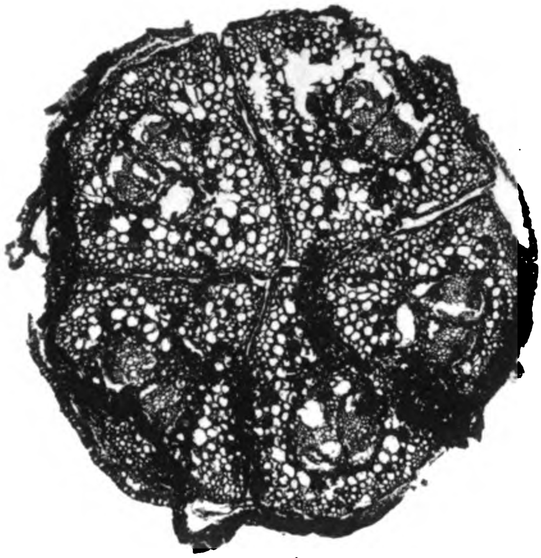

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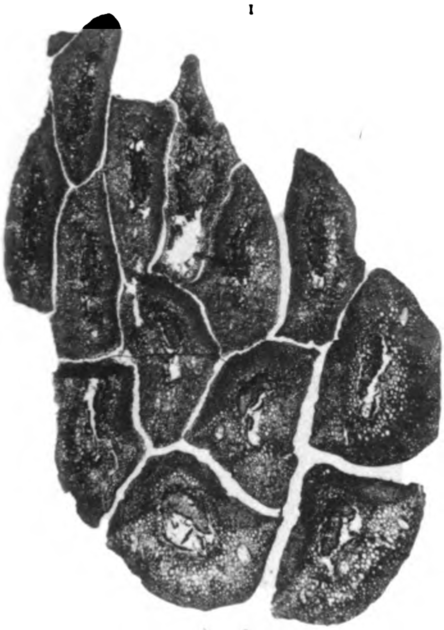

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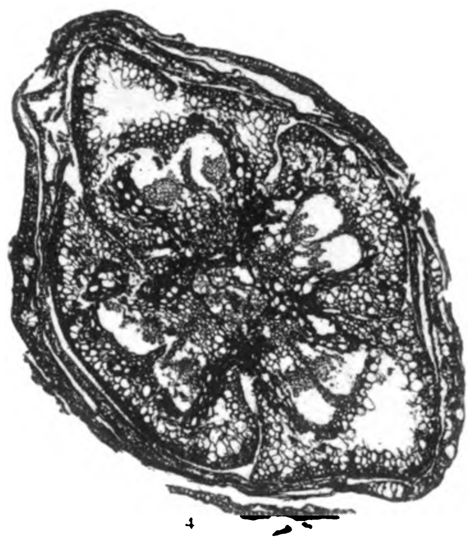

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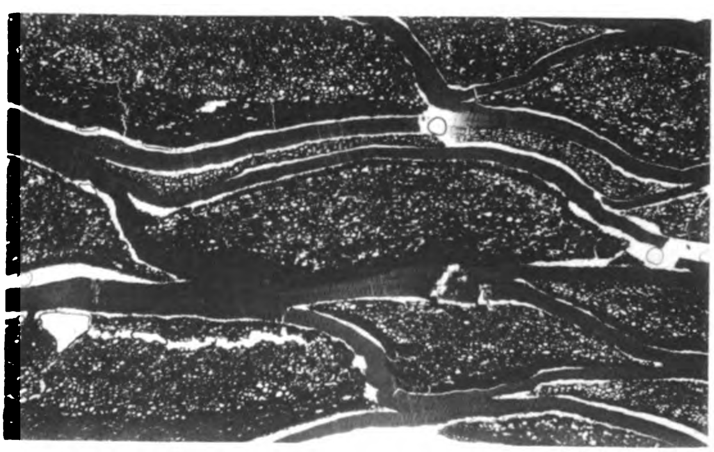

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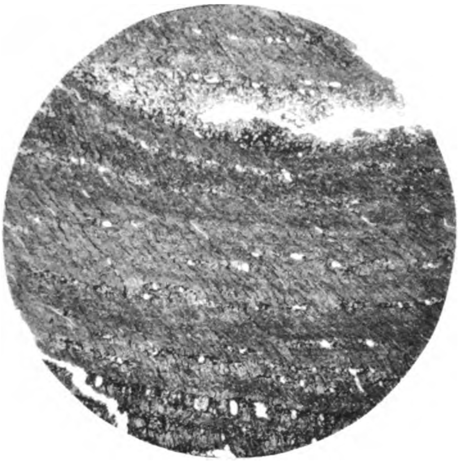

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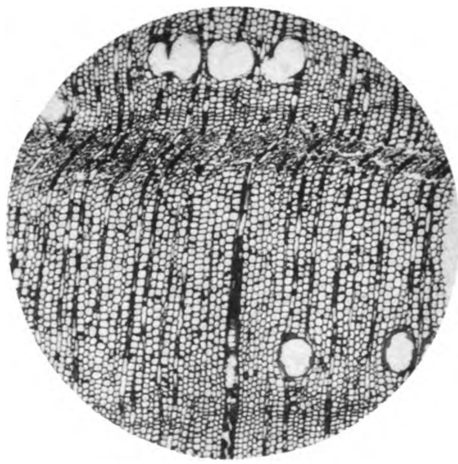

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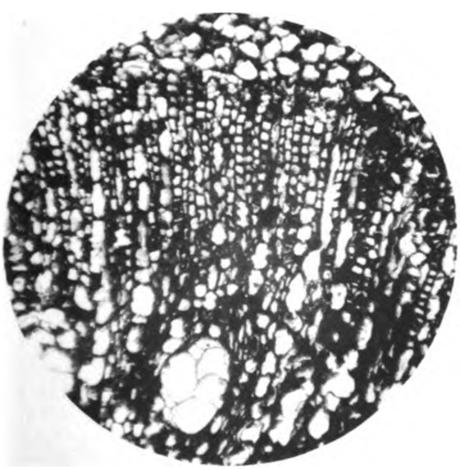

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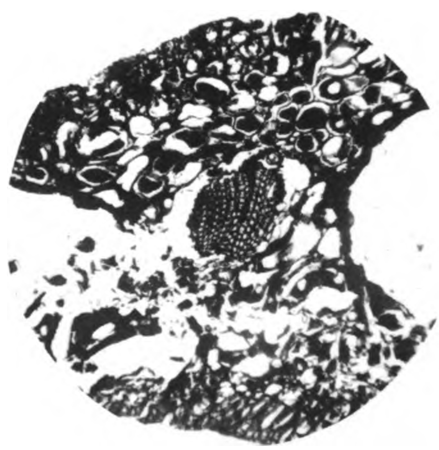

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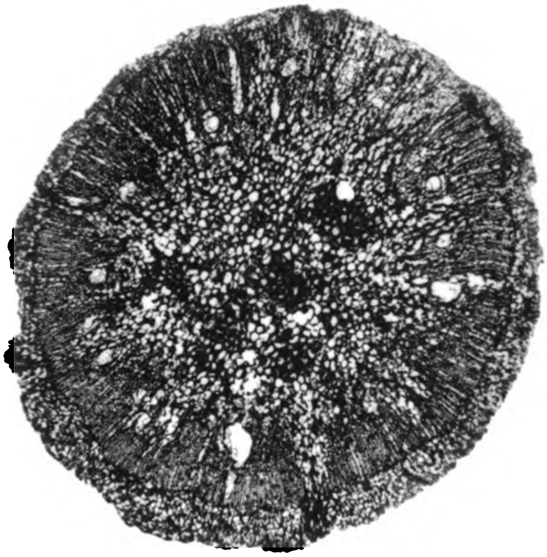

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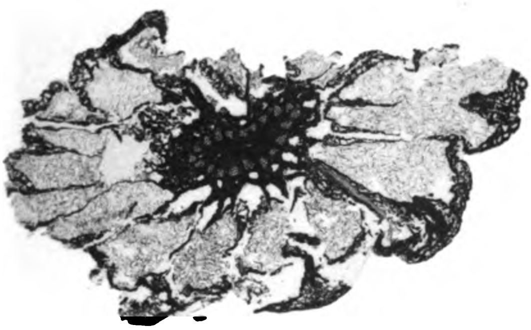

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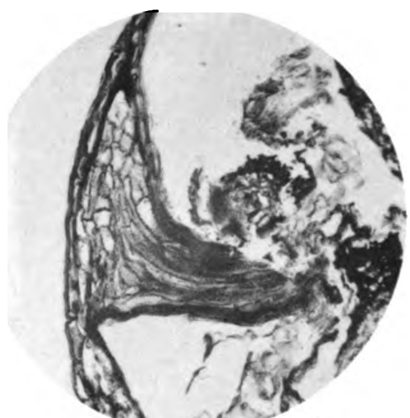

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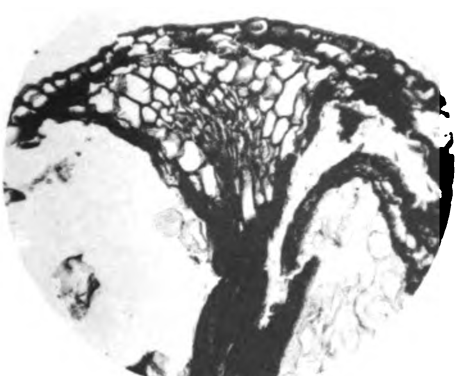

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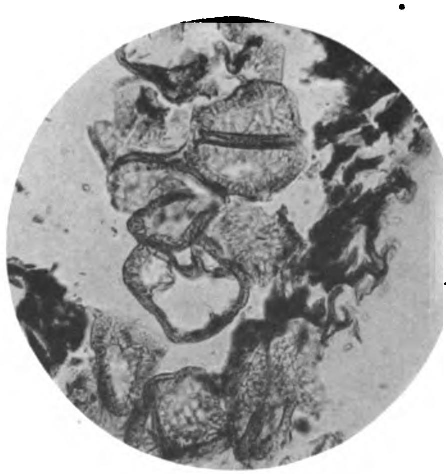

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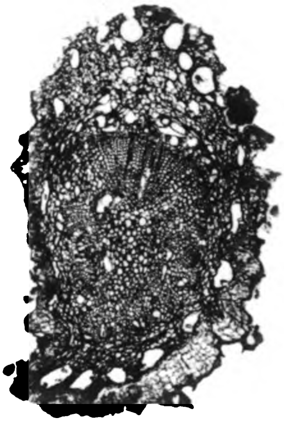
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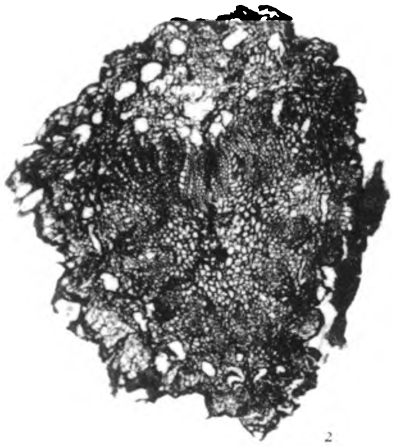
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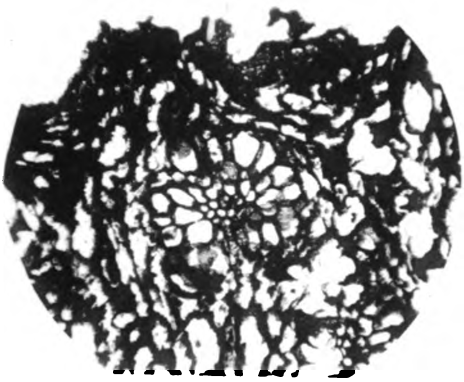
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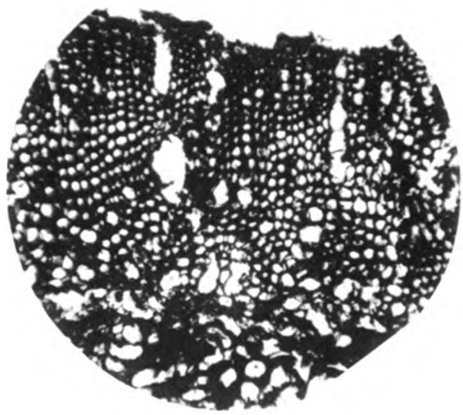
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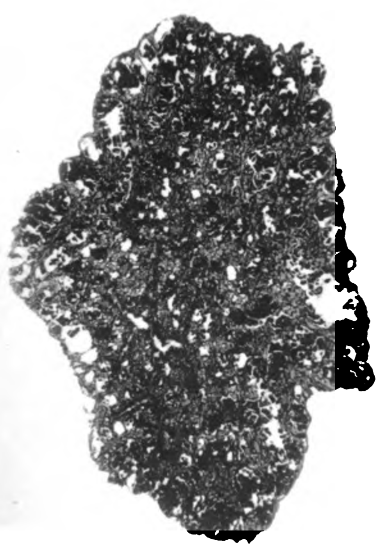
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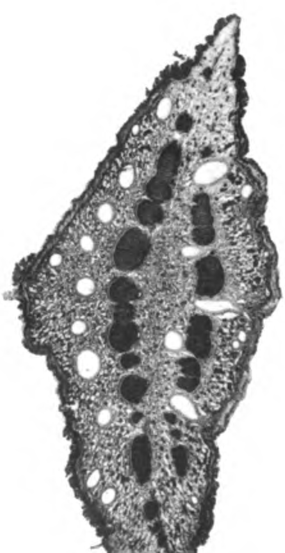
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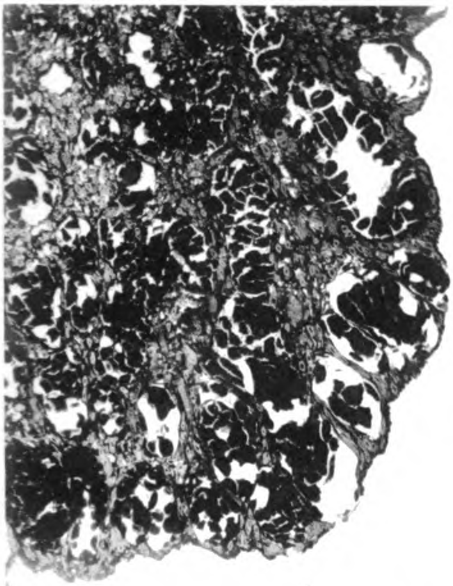

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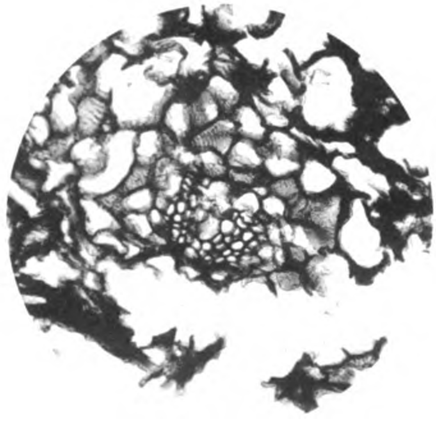

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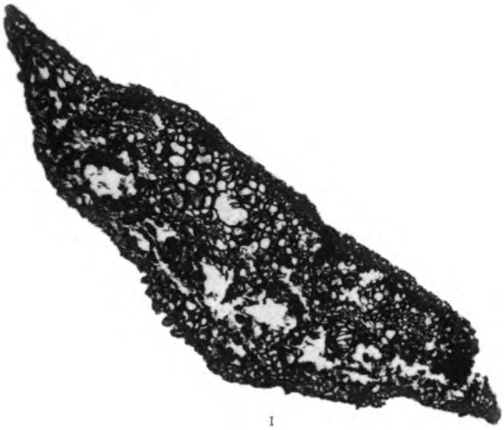
CRETACEOUS CONIFERALES.

PLATE 27

PLATE 27

		PAGE
Figs. 1–3.	*Pityoidolepis statenensis* sp. nov.	53
	Fig. 1. Transverse section through the lower part of a cone scale, × 25.	
	Fig. 2. Similar section of part of the same specimen, showing the double system of bundles, × 100.	
	Fig. 3. Similar section of one of the bundles of the same specimen, surrounded by transfusion tissue, × 100.	
4–6.	*Thuites* sp.?	31
	Fig. 4. Transverse section of the twig fragment shown in fig. 18, Pl. 8, × 35.	
	Fig. 5. Similar section of the same specimen taken at a higher plane of the internode, × 35.	
	Fig. 6. Part of the section shown in fig. 4, × 45.	



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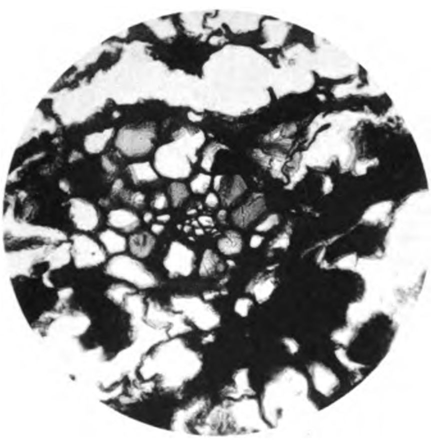

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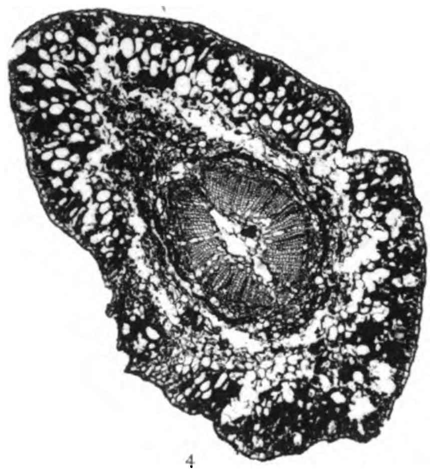

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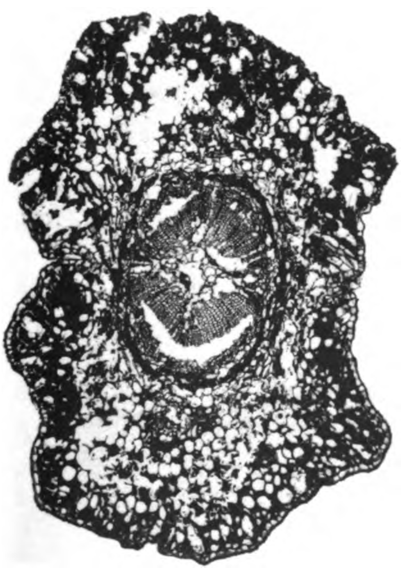

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CRETACEOUS CONIFERALES.

PLATE 28

PLATE 28

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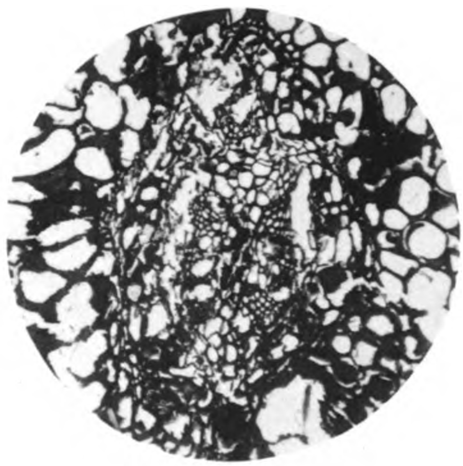

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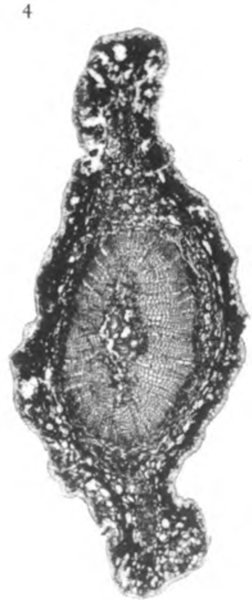

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CRETACEOUS CONIFERALES.

PLATE 29

PLATE 29

Fig. 1. Transverse section through the basal part of an unusually large phylloclad, × 30.

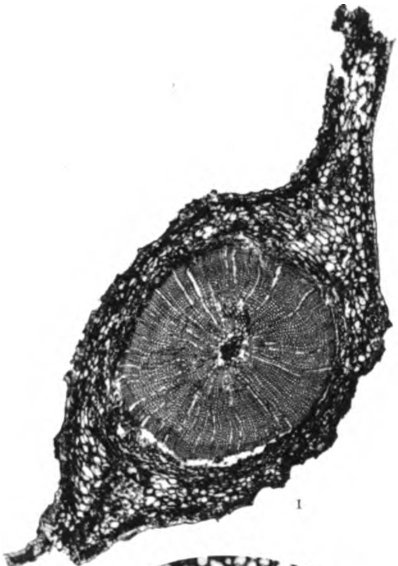
Fig. 2. Median part of the transverse section shown in fig. 7, Pl. 28, × 45.

Fig. 3. Part of the woody cylinder of the transverse section shown in fig. 1, Pl. 29, × 180.

Fig. 4. Longitudinal section of the wood of the specimen shown in fig. 8, Pl. 28, × 180.

Fig. 5. Similar section of the wood of the specimen shown in figs. 1 and 3, Pl. 29, × 180.

Fig. 6. Part of the section shown in fig. 5, Pl. 29, × 500.



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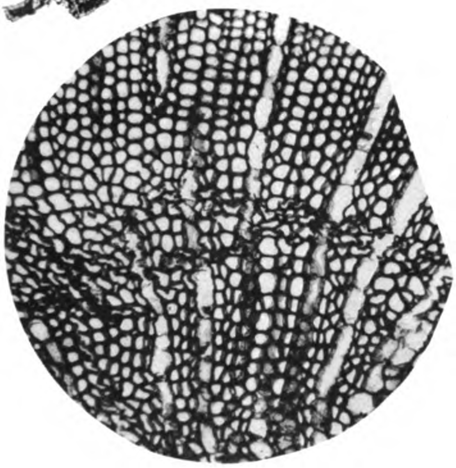

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[Names in **black-face** type represent new species or new combinations. Names in *italic* represent synonyms or species incidentally mentioned.

Numbers in **black-face** type refer to pages on which descriptions begin. Numbers in *italic* refer to pages of plate explanations.]